THE TELEGRAPHIC JOURNAL AND

Electrical Review.

VOL. XIV.—No. 340.

UNDERGROUND ELECTRICAL CONDUCTORS.

LAST week we made some remarks upon the recent judgment delivered by Mr. Justice Stephen in the case of the Wandsworth Board of Works, and on the undesirability of placing wires used for electrical communication, especially those intended for telephonic intercourse, underground. It would be useless to repeat here the scientific objections to such a course which we have at various times enumerated, for objections of a scientific nature do not generally affect local authorities or vestrymen, these gentlemen being, above all things, "practical" men with a supreme contempt for theoretical argument. Our readers are aware that for some time past an American committee has been busily engaged in searching through a number of patented plans or systems for underground electrical communication. No less than six hundred patents have been examined and carefully classified, and the result appears to be disappointing in the extreme. In fact, the committee is obliged to confess that no system submitted or investigated fulfils all the requirements so satisfactorily as a properly constructed tunnel of sufficient size to admit the passage of workmen and access to the wires within it. "But," adds the committee, "the multiplicity of subterranean structures in New York might tend to operate disadvantageously, if not to prohibit the construction of such a tunnel, unless the same were arranged to accommodate the gas, steam and other systems as well as the electric wires."

We should imagine that the difficulties to be met with in the way of already existing subterranean structures in New York would be felt almost as severely in London were any attempt made to construct such a tunnel as would be necessary to contain even electrical conductors alone. We need only point to the engineering obstacles which had to be overcome in the formation of our Metropolitan underground railway, particularly in those sections which traverse parts of the City.

Such a plan has oftentimes been proposed here, more especially since the introduction of electric lighting, but, so far, the idea has not advanced beyond the visionary stage.

If it should ever become compulsory to place all electrical conductors in this country underground, it will be seen that the mechanical difficulties in effecting this object, although not insuperable, will still be very great, and the undertaking a most arduous one. This task, however, will be far easier to overcome than will those electrical drawbacks to commercial telephony, which commence with the burying of the wires; at all events it would necessitate the employment of instruments other than those now in use.

Probably nine out of every ten patents taken out for underground systems of electrical conductors are for some special form of gutter, tube, or conduit in which to place the wire, and we believe that the American committee found but one specification for a *system of conductors* which was thought worthy of an extended description. Even this, which will be found in our other pages, is not considered, in the absence of any experiments, to be sufficiently convincing to the committee to report definitely upon.

Would it not be well, pending any further law-suits and legal decisions on these matters, which may again be upset on appeal, for the Board of Trade aided by proficient experts, to thoroughly investigate the subject with a view to arriving at an absolute determination? Were this entertained and accomplished in a complete manner, we should, knowing already the principal facts concerning overhead wires, have no difficulty in settling the vexed question in point.

SUBMARINE CABLES.

(*Continued from page* 415.)

Mr. CROMWELL VARLEY said he could answer some of the questions put by Professor Tyndall. He had consistently recommended to the Electric and International Telegraph Company the use of wires of large diameter, for the last twelve years, as the only means of obviating the difficulties experienced on long circuits in wet weather from leakage, which, with the earlier forms of insulator used, was very great. Since the introduction of submerged wires he had pointed out the advantage that would be gained in such circuits of great length by the use of copper wire of large sectional area. On his recommendation the directors of the above-named company had tried both of these experiments on a large scale. They had erected iron wires of No. 3 wire gauge on the Great Western, and the London and North-Western Railways, instead of the usual size (No. 8). The results were such that he had no doubt they would never again, for long circuits (viz., of over 200 miles in length), erect other than thick wires. They had tried thick wire under the sea in their new cable connecting England with Holland. This cable contained four conductors of No. 13 instead of No. 16 wire, and although, for reasons explained further on, the relative speed of this compared with that of the former size was not so great, yet there was a very decided gain in rapidity, together with much stronger and much more uniform and reliable currents. These wires were connected both in England and Holland with a considerable length of overground wire, which latter was much affected by changes of the weather, and the gain in unfavourable weather from using the larger wire, was, as predicted, very considerable. He was very much surprised to find Mr. C. V. Walker adhering to, and supporting, views which other well-known electricians had put forward, viz., that increasing the sectional area of the wire did not increase the rapidity of the transmission of electric signals. The experiment, however, had lately been tried in the new Dutch cable, and although the relative speed was not exactly known because there were many difficulties in the way, yet the fact was established that increasing the sectional area had greatly increased the speed. He

had tried to determine the effects of induction, &c., on the speed of the electric wave ; not only had the inductive effect to be taken into consideration, but also the absorption of electricity by the surfaces of the dielectric, and these influences were ever changing by heat and by the charging of the wire to such an extent that approximate results only were obtainable, which, however, were sufficiently near for all practical purposes. The absorption of electricity by the surface of the dielectric required time, and therefore cables of such length and dimensions as would only work slowly, suffered more from this absorption than shorter and quicker ones. The retardation of the wave in a cable was caused by the lateral induction absorbing part of the electricity intended to give the signal through the line, and until this charge approached the maximum the current at the distant end would be weak. If two cables were made, the one with an iron and the other with a copper conducting wire inside the gutta percha, all other things remaining the same, the former would have as much induction as the latter, because this had reference only to the surfaces of the dielectric. As the iron wire would only conduct at one quarter the speed of the copper, it would require, with a given electromotive force, four times as long to transmit a given current. The electricity would require, in the case of the iron wire cable, four times as long to charge the gutta percha, by lateral induction, as the copper wire would, consequently such a cable would have only one quarter the speed of the other. Were it possible to compress twice as much copper into the same diameter, and so double the conducting power without increasing the inductive surfaces, the speed would be immediately doubled. This was not possible, and the effect could only be obtained by increasing the sectional area of the wire ; increasing this four times, doubled the interior surface of the gutta percha, which was the chief inductive surface, and, leaving out of consideration for a moment the exterior surface, the conducting power would be quadrupled while the induction was only doubled : hence there would be a gain in speed of from 1 to 2. But there was more still than this gained ; first, suppose the diameter of the small wire to be unity, and the thickness of the gutta percha covering also unity, the exterior surface of the gutta percha would be 3, and the combined surfaces of the gutta percha would be $3 + 1 = 4$. In the second case where the copper wire was doubled in diameter, and quadrupled in weight, there would be two for the inner surface of the gutta percha, and four only for the outer surface, instead of six—collectively, six instead of eight. Hence, doubling the diameter more than double the speed. The third gain from the large wire was, that, having a higher speed, there was less time for the absorption of electricity, and consequently, the disturbance and retardation from this cause were less. Having a current of four times the power entering the cable, and the leakage being less in proportion to it, the current received at the distant end would be more than four times as powerful, and much more regular ; the apparatus would be less frequently interrupted for adjustment, and would, consequently, work without intermission for a much longer period than the smaller wire. Mr. Walker had alluded to the Atlantic cable, and stated, in proof of the sufficiency of the diameter of the copper wire, the fact that a single element of a water battery gave a current perceptible at the other end. He (Mr. Varley) contended that this proved nothing as to its ability to transmit intelligible signals. In an Atlantic cable we must have not only a wire capable of giving currents and signals, but of giving such currents and signals as should overcome the friction and inertia of the apparatus used for indicating them ; these currents must be so powerful and constant, that, when the philosopher had left the cable to the ordinary manipulator, the currents should not fluctuate so much as to interrupt the intelligibility of the communications. The current must have such force, that the varying friction of the apparatus should not materially influence the recording of signals. In the Atlantic experiment these difficulties were overcome to a great extent by a most ingenious little instrument—Professor Thomson's reflecting galvanometer. In this instrument the only friction was that of a single thread from a silk cocoon, supporting a very short magnetic needle, only $\frac{1}{8}$ of an inch in length, which carried a small mirror made so light as to weigh only a grain or two. The mirror reflected back through a lens a ray of light, and thus without impeding its free action, or adding to its friction, a long but imponderable arm was added to the needle to magnify its motion. This little needle was rendered more or less nearly astatic, by placing a large magnet under it to neutralise the earth's magnetism, and thus a nearly astatic instrument, sufficiently rapid in action from its small dimensions, sufficiently sensitive by its long imponderable arm (or ray of light), sufficiently free from friction by being suspended from a filament of silk, was obtained, and by it the faint signals through the cable were rendered visible. These signals were watched by a clerk, and recorded by hand on a Bain's printing machine. He (Mr. Cromwell Varley) felt that sufficient credit had not been given to Professor Thomson for this instrument, without which the Atlantic cable would never have transmitted a single message, and the world would not have had this great experiment to guide them, as there would have been no means of ascertaining whether the cable had reached the bottom of the Atlantic without parting. Such an instrument, however, was not calculated to meet the requirements of a commercial undertaking, because the reflected spot of light was difficult to follow with the eye for any length of time, and was often recorded by the manipulator incorrectly. The current must have sufficient force to record itself. With regard to the insulating properties of gutta percha, when pure and free from moisture he had found it to rank amongst the best dielectrics, but this was not the condition of the gutta percha used on cables, which appeared to be porous and to contain moisture. When the gutta percha was sufficiently heated to free it from this, there was great danger of altering its character, and rendering it liable to become brittle and to crack. In the Atlantic cable, even before it had been put under water, the loss of current by leakage was so considerable that less than one-third of the original current only reached the distant end. Were the loss constant in quantity it would not so much matter, but wherever the current escaped through moisture, there was polarisation and ever-varying resistance at the leaky spot. As an example, he would quote one of many similar cases that had come under his notice. In one of the London and Liverpool wires, there was a defect in the Kilsby tunnel, caused by a filament of wood in the gutta percha, which was wet at this spot. This leak gradually got worse and worse, and sometimes offered a resistance equal to ten miles of the line composing the circuit, and at other times, especially after the continuous passage of a positive current for some length of time, it offered a resistance equal to more than a thousand miles of the circuit. The fault was situated nearly half way, roughly speaking 100 miles from the end, and when it offered a resistance of only 10 miles, $\frac{1}{11}$ only of the current from London reached Liverpool, assuming the rest of the line perfectly insulated, When the fault from polarisation, &c., offered 1,000 miles resistance, the current which reached Liverpool was $\frac{10}{11}$ of that which left London ; these fluctuations sometimes took place in a second of time. The formulæ for such a case was $e = \frac{\text{E}\, l}{l + y}$, where e was the current received at the distant end, E the current leaving the original station (London), l the resistance of the leak, and y the resistance of the line between the leak and the receving station. Now in the former case, the current was amply powerful enough to work the instruments, and no inconvenience would have been experienced had the fault remained constant, but on the contrary, it was always varying in force, and to such an extent that it was impossible to work the line through only 200 miles in length. Thus it would be seen that, leaving out of the question induction, and its consequent diminution

of speed, a conductor of sufficient size must be had to cause these leaks to bear only a small proportion to the current transmitted, in order that the received signals might be sufficiently regular and equal in force to record themselves with certainty and ease. Unless these conditions were attended to, the cable, as a commercial undertaking, would inevitably fail. With regard to the rapidity of conduction of the electric current, his opinion was that the current began to flow from the distant end *immediately* after the near end was connected to the battery. Electricity showed no signs of compressibility or elasticity, and was without inertia. Suppose, for a moment, that a cable was divided into several portions, each of which was without appreciable resistance, but separated from the next portion by a given resistance, the first portion, on coming in contact with the battery, would be instantly charged, and as instantly would begin charging the next portion, but to a lower degree than itself; this second portion as instantly charged the third portion, to, of course, a still lower degree; and this the next, and so on to the end. By careful reasoning on the known laws of electricity he had come to the conclusion that the current began to flow out of the distant end instantly, but so feebly at first that the most delicate instruments failed to show it. Before concluding, he would draw attention to the unhappily-chosen terms, "quantity" and "intensity." What in England was generally understood by "quantity," was in Germany termed intensity or I. What in England was termed "intensity" or tension, was the electromotive force; in other words, the $I = \frac{E}{R}$, where I represented the power of the current to decompose a given quantity of an electrolyte, E the electromotive force of the current, and R the resistances of the circuit. These terms had unfortunately led many into error, more especially the word "intensity."

Mr. C. W. SIEMENS agreed with much that had been said in the paper. He was decidedly in favour of a large conductor of the very best specific conducting power; and had maintained from the first that the conductor of the Atlantic cable was totally inadequate. When he read a paper last year before this Society, he had expressed the laws by which the proportion of an electric cable should be regulated for a given length by a simple formula; and he thought that a mathematical expression properly explained was preferable to an explanation in words only, even for a popular assembly like the present, because it combined all the elements to be taken into consideration. He did not agree with Mr. Varley that an electric wave on entering a submerged conductor at one end presented itself, in however slight a degree, instantaneously at the other. The laws of induction and conduction, as he understood them, were directly opposed to such an assumption; and in his own experience he had certainly never observed any indication of it. The line expressing the relative amount of charge at different points of the electric wave in the conductor, was expressed not by a dynamical curve, as Mr. Varley had shown it, but by a straight line, terminating abruptly upon the horizontal line which represented the conductor. Another portion of the paper dealt with the complete metallic circuit in submarine conductors, which it was generally understood had been first proposed by his (Mr. Siemens's) brother. Mr. Siemens could not agree with the views expressed by Mr. Varley, and by several others who had lately written in the scientific journals upon this subject. Some of them seemed to lose sight entirely of the most essential condition, namely, that the two conductors were to be embedded in the same insulating medium. His brother had never for a moment assumed, as seemed to be supposed, that lateral induction between the two conductors constituting the circuit would be obviated. On the contrary, it would be rather increased on account of the greater resistance of the metallic circuit. But it was maintained that the charge between the conductors and the larger surface of the sheathing would be nearly entirely obviated; that the working of one metallic circuit in a multiple cable (which his brother had chiefly in view) would not disturb the electrical equilibrium of the other conductors; that the losses by leakage would be reduced, enabling him to reduce also the area of the conductor, and thereby also the lateral induction between them, that the metallic circuit was not affected by magnetic storms, and finally that considerable advantage could be obtained by the mutual acceleration of the positive and negative currents by Volta induction. So long as a single conductor could satisfy the public demand for messages, the advantages of a metallic return wire would probably not warrant the additional expense, but wherever several conductors became necessary, the advantage of working through metallic circuits would be very great. Mr. Varley's illustration of surrounding the one conductor by the other (in the form of a tube) did not meet the case, because the tubular conductor possessed the very condition which it was intended to avoid, namely, an extended inductive surface both against the inner conductor and the outer sheathing. Mr. Siemens had only one other point to remark upon, and that was of an historical nature. Mr. Varley had stated that Mr. W. Siemens had first employed gutta percha coated wires in Prussia in 1850, where he had observed the phenomena of induction also. It was, however, in 1847 when the first gutta percha coated line wire was laid down successfully near Berlin; and he (Mr. Siemens) exhibited specimens of it, and explained the phenomena of charge which had been observed, before this Society in 1848. He might also observe that the statements which had been circulated, that the gutta percha coated wire, as first prepared in Prussia, had proved an entire failure, were very unfair towards his brother. These wires had been coated in the same manner as they were at the present day, although it must be admitted that the quality of the gutta percha employed was very inferior. These lines had, however, done good service for four or five years, when they began to fail; some of them had, however, lasted much longer, and some—covered with lead—were actually in use to the present day. He did not think that a much more favourable result had since been obtained elsewhere.

Mr. LEONARD WRAY said he would make but a few brief remarks upon some of the points under discussion. In the first place he considered that the paper read by Mr. Varley was a very valuable and instructive one, for which all present must feel indebted to him. Let the ideas brought before the Society that evening be designated as mere conjectures, or theories, or what not, still he ventured to differ from Professor Tyndall's opinion, that Mr. Varley should have confined them to his own breast until he had fully tested and proved them practically, inasmuch as Mr. Varley, by giving publicity to them before that Society had, in fact, laid them before the whole world of science, and the result would be, that instead of these ideas remaining stored up in his own mind alone, to be worked out solely by his own individual energies, there would now be many, very many, minds brought to bear upon them, and to assist in reducing them the more speedily to the test of practical experiment. The next point he would remark upon was the best diameter for the conductors of electric telegraph cables, a subject which was so very much discussed, and so very little disputed, that he would only present to the notice of the Society one very singular and significant fact bearing upon the question. When telegraph wires were first introduced into India, Sir W. O'Shaughnessy and his staff were sadly annoyed by the continual breakings of their wires, caused by very large birds alighting upon them. To remedy this nuisance that gentleman employed very thick, strong wires, which these birds could not injure; and this great increase in the size of the wires brought out the remarkable fact that no insulation whatever was necessary at the posts, around which they were simply wound. This deserved, he thought, to be recorded in such a discussion as the present. The third and last subject to which he (Mr. Wray) would refer, was that of insulation. Now, the substance almost universally

used as an insulating material was gutta percha; but they were told, and many of them knew it as a fact, that gutta percha absorbed no inconsiderable quantity of electricity; indeed, that it became, to a certain extent, saturated with it. Such being the case, it must be evident that gutta percha was by no means a perfect insulator, for he held it as an axiom, that no really good and perfect insulator would absorb electricity. The greater the quantity of electricity absorbed by the insulating material used, the greater would be the retardation of the current. Hitherto, then, a substance had been employed which was very far from perfect, and all calculations had been based upon its known insulating properties; but if they had a superior—a very much more perfect insulating material—would it not be possible to construct cables with a far less quantity of that material than gutta percha? He thought so, and he moreover believed that such an insulating material as he had spoken of would, very probably, be soon discovered.

Mr. S. ALFRED VARLEY said he had but little to reply to, as no attempt had been made to refute the views he had brought forward. He was unable to follow Mr. C. V. Walker throughout, and he did not clearly see the direction in which his views tended. Mr. Walker appeared to object to the statement made, that there was a difference between an ordinary Leyden jar and a submarine circuit; yet he admitted that the conductor united the inner and outer coatings of a submarine wire when regarded as a Leyden arrangement, and that the resistance it opposed was the only thing which prevented the free flow from the one to the other. Now he (Mr. Varley) thought this was a most important admission, for upon it depended the reason why a large wire conducted more rapidly than a smaller one, and this was no longer a theory, but an ascertained fact. If there were no difference between a submarine wire and an ordinary Leyden jar, and if a submarine circuit had to be charged statically to saturation before signals passed, as was stated to be the case by the advocates of the small wire system, then it would be clear that as the greater the sectional area, the larger the Leyden arrangement would be, there would be more retardations with larger conductors, as more electricity would be required to charge them. He maintained that, in practice, a submarine circuit was not charged to saturation; the degree to which it was charged statically depended upon the relative balance between the conditions which favoured induction and conduction; if the conditions, as had been stated in the paper, favoured conduction, there would be less statical charge, and a greater proportion of the electrical impulse would be directed forward, and signals would be obtained more quickly. He fully concurred in all the views expressed by Professor Tyndall, and quite agreed with him as to the desirableness of searching for facts with actual submarine circuits of varying dimensions; but when these were not at command, he thought we should not wait for such favourable conditions for experimenting, but should endeavour to obtain the best substitute we could. Moreover, if it were possible to obtain all the conditions which submarine circuits presented in our own private laboratories, this would be a positive advantage, for the whole being under immediate command, and not disturbed in any way by atmospheric causes, more or less defective insulation, or other disturbing influences always occurring in practice, we should be enabled to trace out principles more clearly, and have fewer sources of error to eliminate. Mr. Siemens, when considering the question of the complete metallic circuit *versus* the earth for one-half of it, objected to the fairness of the diagram in which one of the conductors was made into a tube. This diagram was introduced, as was stated in the paper, as an exaggeration, simply to show the fallacy of the principle; and although, as was stated by Mr. Siemens, the wires would not, when side by side, present as much surface to induction as an ordinary circuit, yet it must be borne in mind that there would be just twice the resistance of that which would be opposed when the earth was employed for one-half of the circuit, and this would more than counterbalance the lessened surface exposed to induction. He agreed generally with the remarks made by Mr. Wray. There was no doubt that with large conductors imperfect insulation was less felt, but the result in Sir W. O'Shaughnessy's case was probably not altogether due to the size of the conductor, for it must be remembered that the climate was very hot and dry. As a practical fact, he (Mr. Varley) would state that when in the Crimea they never obtained what telegraphists termed a "perfect earth." In the submarine circuit between Varna and Constantinople, contact with the earth was made by connecting a wire to the iron sheathing of a piece of the cable, more than a quarter of a mile in length, which was buried in the earth, and passed through the British Embassy grounds, yet, notwithstanding this extensive surface, in hot weather he found the earth, to use a telegraphic expression, very far from "perfect," and he remedied this by carrying a wire out into the Bosphorus.

The CHAIRMAN said, before proposing the usual vote of thanks, he would express his opinion of the result of the discussion that evening. They had advanced very little in practical knowledge since the failure of last year with the Atlantic cable; but the proper way of doing so was to follow the course pointed out by Professor Tyndall. At the same time he thought it was well that theories should be advanced with a view to set men thinking; but the professor no doubt meant to pay Mr. Varley the compliment that his knowledge of this matter would be better applied to the practice than the theory of the subject. But Mr. Varley was, in fact, doing what had been asked of him; and it was only owing to some delay in the completion of an elaborate instrument that he was not able to lay before them the results of actual experiment. The *experimentum crucis* was what they really wanted; wires of different conducting powers tested against each other, and the results ascertained by the best class of instruments, and, he would add, by a variety of experimenters. He found that electricians still remained true to their colours, in the absence of positive results, one way or the other. His friend, Mr. Walker, still adhered to the small wire, whilst others appeared as the consistent advocates of a large wire as the best conducting medium. In this country such opportunities were presented for experiment upon a large scale, that they had nothing to fear from theory; and he hoped such experiments would be made as would solve many of the points upon which so much diversity of opinion now prevailed.

THE CROMPTON-CRABB ARC LAMP.

WE have been favoured by Mr. Gisbert Kapp with sketches and a short description of the Crompton-Crabb patent double carbon arc lamp. The apparatus appears to be very simple, and its various parts have evidently been well studied.

Fig. 1 shows the lamp, frame, shade, and globe. B, B, are rack rods, O, O the positive carbon holders, A a T-shaped rod supporting the negative carbons in the bottom carbon-holders, O_1, O_1; M is the main solenoid; G a shunt solenoid; E, S and E_1, S_1 are sleeves embracing and sliding on the rack rods, and they are provided with heels, F, F_1, resting on the levers, L, L_1. If these levers are inclined downwards they allow the wheels to turn freely, but if by the pull of the core of the solenoid the levers are pulled up into a horizontal position the wheels rest on the levers, and are thus braked. The spindle of each wheel is provided with a pinion, gearing with its rack rod, thus controlling its movements. One of the heels is a little longer than the other, thus allowing one pair of carbons to come in contact before the other pair, but when the first pair are consumed the other pair are, by their own feeding arrangement, automatically brought in. In other words, the simple expedient of making one finger longer than the other determines which pair of carbons shall begin to burn

first, because on switching on, that pair which has the longer finger will be the last to break contact, and will, therefore, originate an arc in so doing. When these have burned low, the rack, B, is prevented from falling lower by a stop; hence the arc will lengthen, the shunt current increase, and the other rod, B, which can still feed, be allowed to descend until its carbons touch, starting a fresh arc, when everything goes on as before. When the second pair of carbons have burned low the arc lengthens and the shunt increases as before, and the core is drawn down, but lower than when the first pair were burned out, until a stud, C, attached to it makes contact with another, H, connected to the negative pole, cutting the lamp out of circuit, and substituting an equivalent resistance.

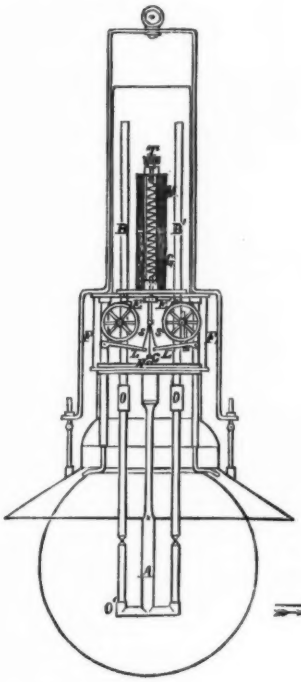


FIG. 1.

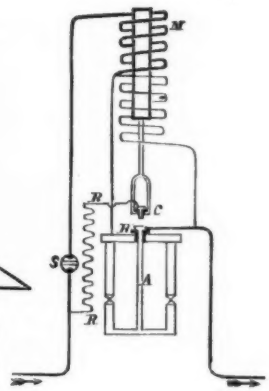


FIG. 2.

Fig. 2 shows the connections of a lamp in circuit, the current taking the direction shown by arrows. S is a switch, which, if closed, puts the lamp into circuit. If open it shunts the current through resistance, R, R, and through the contacts, C, H, on to the next lamp. If the current through the lamp be interrupted, either through opening the switch, S, by the hanging up of the rack rods, or by the carbons falling out, the main solenoid, M, loses its power, and allows the core to drop and make contact between C and H.

We understand that these lamps can be burned in parallel connection from a compound dynamo. If used in this way the shunt solenoid of each lamp is disconnected from the lamp terminals, so that the feeding is under the control of the main only. The lamps are constructed for 16 hours' burning, and the electromotive force required is about 50 volts.

The Army Field Telegraph Corps. — The Manchester, Birmingham, Edinburgh, Glasgow and Hull detachments of the Field Telegraph Corps, Post Office Rifles, were inspected in the grounds of the Charterhouse, London, on Friday week, by Colonel Du Plat Taylor. The men belonging to this branch of the Post Office Rifles now number about 200. War Office authority has been received for the enrolment of 100 of them for service with the regular army. The appearance of the detachments on parade was all that could be desired. After the inspection those who had volunteered for service with the regular army were examined and enlisted.

TELPHERAGE.*

By PROF. FLEEMING JENKIN, LL.D., F.R.S.

THE arguments which have induced the author to devote much time and labour to telpherage may be stated as follows:—

We could not with steam employ a vast number of little one-horse engines to pull along a number of small trains or single waggons. There would be waste in the production of power, and great cost in the wages of the men employed at each engine. But an electric current, of, let us say, 50 horse-power, will, as it circulates through a conductor of moderate size, drive thirty small engines each of one horse-power, which require practically no supervision, and can be made nearly as economical in their action as a single electromotor of 30 horse-power could be.

But if the power can be distributed economically along a line, say, ten miles in length, this allows us to employ thirty small trains, corresponding each to a waggon pulled by one horse, instead of a single train such as might require 30 horse-power. If we further distribute the weight by making each train of considerable length, we are able to employ an extremely light form of road, such as a suspended rope or rod of, say, ¾ in. diameter. In distributing the power by means of electricity, it was clear that considerable waste must be incurred, but the amount of that waste is easily calculated, and is by no means prohibitory. Moreover, the power, being obtained from stationary engines, or in certain cases from falls of water, could be produced at a cheap rate in comparison with that obtained from locomotives or traction engines.

When I examined the various forms of possible road by which the distributed power and distributed load could be conveyed, it seemed to me that the single suspended rope or rod offered great advantages. The smallest railway involved embankments, cuttings, and bridges, fencing, and the purchase of land. A single stiff rail, with numerous supports, from which the train might hang, seemed better, and may, in some cases, be employed, but the supports would require to be numerous—say, one post every 10 or 15 feet—and even with these spans, the girder required to carry vehicles weighing 2 cwt. each, would be costly. With a single suspended rod or rope, we may have supports 60 or 70 feet apart. A ¾-inch rod, thus supported, will carry five vehicles, each bearing 2 cwt., without excessive strain. No purchase of land is necessary, no bridges, earthworks, or fencing. The line can be so far removed from the ground that it will not be meddled with, either by men or animals. A single wheel-path gives the minimum of friction, and the rolling stock can be much more easily managed than if we attempted to let vehicles run on double swinging ropes. On all those grounds it seemed well worth while to devise means by which trains could be electrically and automatically driven along the single suspended rod. (The author then described the general system of telpherage as applied on the experimental line at Weston. Of this system we gave a full description in the No. of the REVIEW for December 8, 1883.)

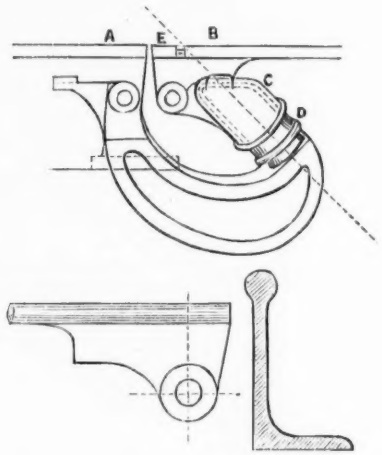
The original line was found inconveniently large and high, and the experiments were continued on a line ¾-inch diameter, of round steel rods, with 50 feet span. This line is continuous, that is to say, it re-enters on itself. It is 700 feet long, and we have run a train of more than one ton at a speed of five miles per hour on this line with complete success. The insulation has given no trouble. It need hardly be said that we see our way to great improvements in details. Thus, we can make the road more uniform, and stronger for its weight; we can lessen the quantity of material used, and greatly diminish the amount of skilled labour required in erection. We can improve the design of the posts. We can improve the trucks and locomotives, so that they will go round sharper angles, and so forth, but the main object has been practically carried out. We have had trains on a scale as large as I am prepared to recommend, running at the highest speed I have contemplated.

The system is not an electric railway destined to compete with steam railways in conveying goods and passengers at high speeds, neither is it a new form of communication destined for small parcels and high speeds; it is simply a cheap means of conveying heavy goods which, like coal or grain, can be carried in buckets or sacks, each containing two or three hundred weight. The speed on a telpher line will be that of a cart, and the object we aim at is to cart goods at a cheaper rate and more conveniently than with horses.

Only one of the two continuous conductors requires to be insulated; this results in alternate insulated and uninsulated sections all along each line. Fig. 1 shows a saddle, as we call it, with an insulated attachment, B, at the one end, and an uninsulated attachment, A, at the other, as used for a short sample line which has just been sent to Peru for the Nitrates Railway Company, Limited. The line itself is a three-quarter inch steel rod with forged ends, and fig. 2 sufficiently shows the mode of attachment. The insulation is given by a vulcanite bell insulator, D, carrying a cast-iron cap, C. All the parts are designed to stand 2·2 tons strain; the vulcanite is secured between two layers of Siemens's cement. The experiments at Weston have shown that vulcanite answers perfectly, but the material is rather expensive. I have here a smaller porcelain insulator, which has been subjected to 2·2 tons strain. I believe porcelain will answer well in all respects, but it has not yet been subjected to the test of actual traffic day by day.

* Abstract of paper read before the Society of Arts, May 14th.

At Weston the vulcanite was used between layers of Portland cement, the only objection to which is, that it takes some time to set. The simple steel rod has been found preferable in all ways to rope. We find that there is less friction and less jar with the rod, and ample flexibility; it is also much easier to secure. Moreover, a solid rod with welded ends can be made so that the ends, where supported, are, to some extent, undercut, as is shown



FIGS. 1, 2, 3.

in the corresponding bulb angle-iron (fig. 3) used for rigid parts of the road, this undercutting allows much greater freedom of rolling than would be compatible with the horizontal gripping wheels, especially when gripping wheels are used which, like those in the model, actually hold on to the line so as to resist being lifted. A short piece, E, slightly insulated, prevents the sections from being short-circuited by the wheels.

Fig 4 shows the posts and crosshead supporting the line. In the one-inch example this design was fully carried out, and the

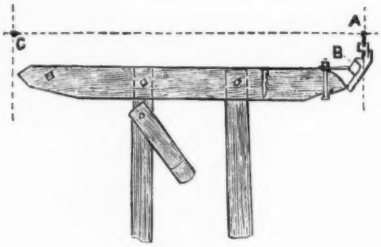


FIG. 4.

posts stood the cross strain due to the overhanging load perfectly. In the five-eighth line an attempt was made to cheapen the construction, but the posts in wet weather work at the foundations; it is well that we are put on our guard against this danger. In the first design a sort of rocking saddle was employed, to allow the strain to be transmitted from one span to the next, but the flexibility of the posts provides amply for this object.

Abutment posts are required at intervals, and these can be made use of to provide compensation for changes of temperature, and to limit the stress on the rods. In straight lines I reckon about four abutment posts per mile.

In the short South American line, curves of 45 degress at the posts will be employed, as shown in the model. At the stations where goods are to be handled, a rigid road will be more convenient than the flexible rod. A bulb angle-iron, like that shown in fig. 3, supported every ten feet, answers well at Weston, and a siding, leading the trucks off this line, has been satisfactorily carried out. The siding leads back to the line at a point between two flexible spans. In fine, it may be said to-night that the problem of the continuous line, whether straight, curved, rigid, or flexible, has been completely solved. Drawings and specifications can be put, without further delay or experiment, into the hands of contractors.

The trucks which have gone to South America have two peculiarities—first, each wheel 7 in. diameter (fig. 5) is pivoted on an axis, D, vertically over the centre of the wheels, A; this allows the truck to run with the freedom of a bicycle round curves; secondly, the weight carried is hung on a swinging arm, D, pivoted to the frame at a point, P, on a level with the line. The result is that any force applied in a plane containing the line acts as if applied at the line itself, and will neither lift the wheels in front nor behind, In the model, the coupling, as you see, is on one line attached to the top of the swinging arm, where the coupling rods are well out of the way. In the other line the coupling is below the road. The swinging arm relieves the locomotive from all jerk at stopping or starting. The truck is completed by a small hook, or

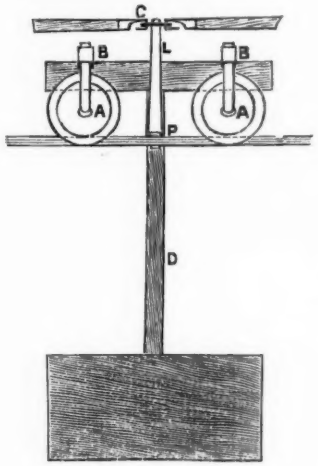


FIG. 5.

catch, embracing the rod. In case of any accident causing the wheels to leave the line, this hook will prevent the truck from falling.

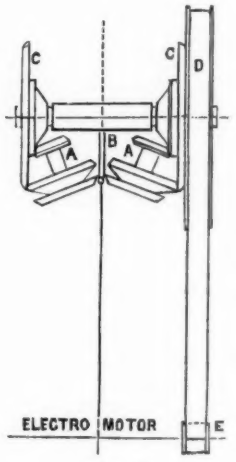


FIG. 6.

Figs. 6 and 7 show a recent form of locomotive designed by Mr. A. C. Jameson, when I was personally unable to attend to work. This locomotive, which is called the belt locomotive, shows

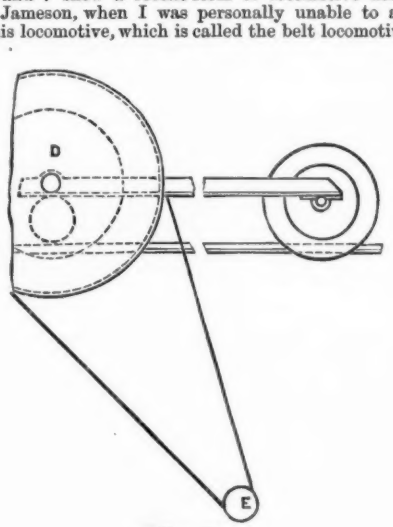


FIG. 7.

a great advance on its predecessor. The general arrangement of the upper nest grip is retained, but a most ingenious modification has been introduced by which the discs, C, C, run on one path on

the rollers, A, A, while the rod runs on another. In this way, the dirt from the line is never conveyed to the driving disc surface between A and C. Moreover, these frictional surfaces, which are points in the first form, have become lines in the second. This head answers admirably. The weight is carried by a roller, B, between the gripping discs, an arrangement contained in one of my first small models, and wrongly rejected in the first large locomotive. With this subdivision of weight, the gripping wheels are much less likely to rise, and can be made very shallow. In the actual locomotive, these gripping wheels are of an open inverted Λ shape, which has certainly run very well, although I prefer at present the upright V shape, which closes under the rail, as used in the model before you. Both of the gripping rollers drive, as in the first type. The cross shaft is driven by a belt on a 20-in. pulley, D; the other end of the belt runs on a 2-in. pulley, E, on the motor spindle. The friction due to the pull of this belt on the motor spindle is relieved by friction rollers. This locomotive runs extremely safely and steadily on the line; indeed I am not aware that it has ever been thrown off.

The following are particulars of its construction:—Weights with 96 lbs. one horse-power motor 269 lbs.; wheel-base 2 ft. 6 in.; diameters of driving rollers 6 in.; 4·94 revolutions of motor per one revolution of driving wheel. A couple of 60·6-in. lbs. on motor is required for 100 lbs. pull at rail. 276 revolutions of motor correspond to one mile per hour on the rail.

The machine requires strengthening in some places. It will, however, be seen that none of these points touch the essential features of the design, which might at once be adopted in practice. Worked with motors of the Gramme type, the additional gear would not be required.

As general features of the train running on the line, I may mention that the deflection of the rod within reasonable limits has very small influence on the resistance. When the deflection on a 50 ft. span was about 2·4 ft., the resistance for a train of trucks, weighing in all 1,260 lbs., was 22 lbs.; and no sensible difference could be detected when the deflection was materially reduced. This resistance was measured by pulling a train along, span after span, by one end of a rope passing over a pulley on the leading truck, and having a weight hanging vertically from the other end of the rope; the weight thus limited the pull. This pull differs extremely little as the train moves along, for when one part of the train is descending the curve the other part is ascending. It should be noted that during this experiment no special care had been taken to oil the bearings, and I have no doubt this pull can be materially reduced.

Quitting generalities, I will give some details as to the electrical and other conditions necessary, in two examples, for what may be considered as typical telpher lines:—

First Line.—Length, five miles. Length of circuit, out and in, 10 miles. Twenty-five trains running at once, spaced one-fifth of a mile apart; speed, four miles per hour. Let each require one horse-power on the average; let the motor take on the average two ampères of electric current; let the electromotive force near the stationary engine be 840 volts; the electromotive force at the end of five miles will be about 746 volts. The total current entering the line will be 50 ampères at the near end of the line. Fifty ampères and 840 volts represent 56·5 horse-power; of this, 6·5 horse-power will be wasted in heating the line; the remaining 50 horse-power will do work in the motors equivalent to 25 horse-power. In order to give this current of 50 ampères with 840 volts, the stationary engine will require to exert $\frac{10}{8} \times 56{\cdot}5$ horse-power, or roughly, 70 indicated horse-power, or somewhat less than three times the useful horse-power. Let us now examine the economical results to be obtained from such a line as this. Mr. Dowson, in an interesting comparison between the cost of horse-power obtained from coal and gas, reckoned the cost per horse power for a 100 horse-power engine, at the rate of £3 6s. 9d. per annum, to include wages, coal, oil, and depreciation. Mr. Dowson would naturally be led to put the cost of steam power obtained from coal rather high than low. I will, however, adopt a very much higher figure, and assume that the power may cost as much as £6 10s. per horse per annum; this gives £455 as the cost of the 70 horse-power required for my telpher line.

Let the 25 trains each convey a useful load of 15 cwt. In a day of eight hours the line will have conveyed a traffic which we may express as 600 ton-miles—*i.e.*, it will be equivalent to 600 tons conveyed one mile, or 60 tons on each line conveyed from end to end daily. If we count 300 working days in the year, the sum of £455 gives £1 10s. 4d. per diem, and the 600th part of this is about 0·604 of a penny, as the cost of the power required to carry a ton one mile.

In Great Britain we ought easily to be able to reduce this below a half-penny per ton per mile, which proves that the apparent great waste, even of two-thirds of the power in transmission, does not involve prohibitory expense. In calculating the whole cost of transport we must further take into consideration the cost of the installation. Taking the spans at 70 feet, I estimate this cost as follows:—

Line, £500 per mile	£2,500
Engine, boiler, and shed, at £20 per indicated horse-power	1,400
Dynamo and fittings	1,000
25 trains	2,500
Contingencies	600
Total cost	£8,000

Allowing 12½ per cent. for interest and depreciation, this represents an annual cost of £1,000. Allowing £100 as the salary of an electrician or young engineer, and adding £455 the cost of the power, this gives a total annual expenditure of £1,555 for a daily duty of 600 ton-miles. If we continue to assume the year as containing 300 working days, the total cost of conveying one ton one mile will be found equal to 2·07d. If goods are to be transmitted for long distances the same calculation applies. We should simply have stations 10 miles apart, working lines 5 miles long on each side of them. This, then, is the practical outcome of the general principles stated at the beginning of this paper. We may expect with great confidence that it will pay investors to convey goods for any distance at the rate of 2d. per ton per mile by the agency of the suspended telpher line.

Matters are somewhat modified when the traffic is smaller. Making similar calculations for a line one mile long instead of five, with only four trains running at once, we might employ an electromotive force as low as 100 volts; the loss by heating would be insignificant; we should require about 12 horse-power; the work done in eight hours would be 96 ton-miles. I estimate the cost of installation at £1,600, and the annual cost of working £344, without the annual salary of an electrician. This corresponds to 2·875d., or less than 3d. per ton per mile. One very important feature in respect to the cost of telpher lines is the fact that the larger part of that cost is due to plant, such as locomotives, trains, and dynamos. This plant can be increased in proportion to the work required; thus there is a very moderate increase of cost in the rate per ton per mile for a small traffic as compared with a large one, and, on the other hand, a line laid down for a small traffic will accommodate a much larger traffic with no fresh outlay on the line itself.

While I do not believe that the suspended telpher lines will ever compete successfully with railways where the traffic is sufficient to pay a dividend on a large capital, I do believe that telpher lines will find a very extended use as feeders to railways in old countries, and as the cheapest mode of transport in new countries. In presenting this view to you, I rest my argument mainly on the cost of different modes of transport, which may, I believe, be stated approximately as follows:—Railway, 1d. per ton per mile; cartage, 1s. per ton per mile; telpher lines, 2d. per ton per mile; and let it be remembered that, in taking the cost of cartage at 1s. per mile, the first cost and maintenance of the road is left wholly out of account; whereas in my calculations for the telpher line allowance has been made both for establishment and maintenance.

DISCUSSION.

Prof. PERRY said he never remembered feeling so much the want of his colleague, Prof. Ayrton, who was unfortunately engaged elsewhere. At a very early period in the history of this invention, Prof. Jenkin did his colleague and himself the honour to associate their names with his own, but their contributions, perhaps because they had in view the future much more than the present, were as nothing, compared to what had been done by Prof. Jenkin. He never seemed to be floored when a difficulty presented itself, but after a month or two, when everybody had fancied the difficulty was insuperable, he showed how he had overcome it. He could only say, therefore, that the success which had been achieved in the special form of telpherage exhibited there that evening was almost entirely due to Prof. Jenkin's efforts.

Mr. ALEXANDER SIEMENS thought that in working out the cost Prof. Jenkin had been in one direction too low and in another perhaps too high. He did not think steam power could be obtained at the rate of £6 per horse-power per annum, but would cost nearer £10 or £12. On the other hand, these lines would be most generally useful, perhaps, in mountainous countries, were water power would be available at much less cost.

Mr. A. RECKENZAUN said Prof. Jenkin had given a most elaborate account of the beautiful working of his telpher line, and he felt certain there was a great future for this method of transporting goods. In many cases, especially in mountainous countries, it would be exceedingly economical, and would be available where a railway would be quite out of the question, from the necessity of making expensive tunnels.

Mr. T. R. CRAMPTON thought every one must have been much pleased with the explanation which had been given, and that most persons would share his feeling of astonishment at the results which had been attained by such simple means. There was no part of the apparatus in which wear and tear might not be reduced to the minimum. The grip could not be expected to last for ever, but it was most simple in construction, and, with the materials at command, could be made to last the maximum time. He thought Mr. Siemens was right in his statement of the probable cost of steam power, in the majority of cases, though no doubt £6 might be correct, if a large amount of power were required, and every modern improvement were brought to bear. The cost of 2d. or 3d. per mile was really nothing for the purposes to which this mode of transit was proposed to be applied. In many cases such a cost would be considered heavy, but in others, such as this would be applied to, people would gladly pay 6d.

Prof. GEORGE FORBES remarked that Prof. Jenkin had evidently not brought forward this invention until he had got it into thorough working order, and he was surprised at the complete success that he had attained so soon. He should like to ask, however, whether he had succeeded in running several trains on the same line. Prof. Jenkin had told them that any number of trains might be run simultaneously, in the same way that any

number of lamps could be switched on to a circuit for electric lighting. But the analogy was not quite exact, because in the case of trains the length of the leads would vary, while in the case of incandescent lamps it was constant. One would expect that the electromotive force would fall off so much between the near train and the distant one, that the near one would overtake the other, and that even an attempt to equalise the resistance of the circuit through each train by a return wire would not be completely satisfactory; and that even with such a device there would still be such a difference of electromotive force as would tend to make one train pick up the other. He should be glad to know, therefore, if several trains had been run on one line. This had been done on an electric railway, where the same difficulty occurred, the only case which had come under his observation being the one at Vienna, but there the conductors of each car had the power of interposing resistances, so as to diminish the power if required. It would be very interesting to know if the same thing could be accomplished automatically.

Mr. WALTER HANCOCK said he had not quite gathered what was the speed which could be obtained on this line, but he thought he understood Professor Jenkin to say that he had attained a speed higher than he considered it desirable to employ.

Prof. JENKIN, in reply, said he had invited Professors Ayrton and Perry to assist him because they had already contemplated working electric railways automatically, and, therefore, the fundamental idea of telpherage was already familiar to them: and knowing their great abilities he anticipated that they could give him valuable aid. It had so happened, from various circumstances, that the working out of this particular form of idea had fallen more especially to his lot, but he had little doubt that, in a short time, those gentlemen would come forward with something quite as interesting as what he had now explained. This being his own particular idea, he had chiefly worked it out, and probably that was the way in which the best work would be done. With reference to Professor Forbes's question he might say that there were a whole set of problems connected with the running of several trains together, which required special attention. Up to the present he had only run two trains, one each way, and there the special difficulty to which he had alluded did not arise, though another did, viz., that if one train ran away, it tended to send all the current through the other, and you had to provide for a certain balancing between the two. It was impossible to go into all the questions of electric arrangements at that moment, besides which he had determined to limit himself to a description of what had actually been accomplished. He might, however, say this much. They had to provide for what might be called the electric governing of the train. Trains must sometimes be run down hill, sometimes up hill, and sometimes on the level; and they did not all take the same amount of power. Each must take just the amount it required, and the electromotive force along the line tending to drive the train must at every point be considerably above that which the train would require at the maximum. With a fall from 840 to 746, it would be easy to realise these condition; but they were really much more complex than Mr. Forbes had assumed, necessitating such an arrangement of the electric governing that each train, while running at the same speed, should take just the amount of power required. At some future time he would explain that, but he preferred waiting until it had actually been done. Meanwhile, to prevent anyone supposing that he had set himself an impossible problem, he would say that he saw his way to doing it without ever interrupting the current, except between the rod and the wheels, where experience already showed that the interruption was harmless, the great difficulty in all these electrical manipulations was, that these powerful currents, which conveyed 1, 2, 20, or 40 horse-power, could not be broken and made without danger of arcing and sparking, and all sorts of difficulties which must be met. The governing which he had described, by means of which just the requisite amount of power should be taken off, existed at the present moment on paper to his own satisfaction, but he preferred not to describe it until it had been tested. The same thing might be said as to the breaking and blocking of trains without interrupting the current, or having a single spark from end to end anywhere except the sparks between the rolling wheels and the line, and there they knew the maximum effect, which had not created any difficulty. With regard to speed, he might say that speed had nothing to do with the power or application of electricity. If a sufficient sum of money was placed at his disposal, he would design trains which should run at a speed of 150 miles an hour; it was entirely a question of cost. Such rapid travelling would cost a great deal, because you must have a rigid road, with very large curves. Where you had a flexible line, in which there were considerable dips, if the trains ran at a high speed, serious strains were thrown upon them, due to centrifugal force in going down the incline and up towards the supports; moreover, the acquired momentum would tend to throw the vehicles off the line at the vertical curves over the posts. He, therefore, looked on the suspended line as essentially a carting, or low speed line. A high speed railway must have a rigid road, and was not the sort of thing he was competing with.

The CHAIRMAN remarked that the concluding observations of Professor Jenkin had pointed out a number of difficult problems which he had had, and which he might still have, to contend with; but they must all have been struck with the charming manner in which he had worked out the subject so far, and they would go away with a feeling of admiration for the manner in which he had applied his great scientific knowledge to this important purpose. He himself could see many directions some of which might not have occurred to Professor Jenkin, certain paths of work in which he was engaged, in which telpherage ought very soon to be introduced, and he had no doubt that there were many respects in which this might be considered one of the most important applications of electricity in the future. He concluded by proposing a vote of thanks to Professor Jenkin, which was carried unanimously, and the meeting adjourned.

COMPARATIVE MEASUREMENTS OF THE ELECTRO-MAGNETIC ATTRACTION OF CYLINDRICAL AND DOUBLE CONICAL CORES IN SOLENOIDS.

By DR. EMIL BOTTCHER.

HERR FR. KRIZIK, described in vol. 3, p. 7, of the "Central Blatt für Electrotechnik," a "Novel action of solenoids upon especial iron rods, and its application in electric lamps." This action, according to my experiments described below, has no existence.

Before examining the subject, I ventured to correct a sentence put forward by Herr Krizik in his introduction. He writes:—"It is further known that the force with which this (iron) rod is attracted into the spiral reaches its maximum when one end of the rod lies in the same plane as the middle of the spiral."

This proposition is in general quite incorrect, and can at most hold good in some particular case. According to my researches, the maximum of the attraction and the accompanying position of the iron core with

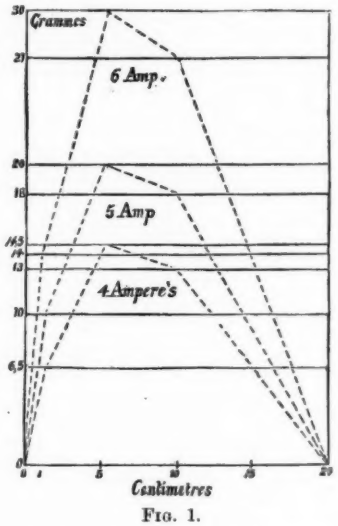


FIG. 1.

relation to the coil of the solenoid depend solely on the mutual relations between the lengths of the two latter. If core and coil are equal in length, we have the maximum of attraction when the core projects out of the coil with one-quarter of its length, whilst the remaining three-quarters remain within. If the core is double the length of the coil, the maximum is given when one half of the core is enclosed by the coil and the other projects out. If the core is three times longer than the coil, the maximum attraction is reached when the coil encloses the first third of the core and the other two-thirds remain free. These proportions hold good both for cylindrical and biconical cores, as may be at once seen from the curves of attraction shown below. Now I arrive at my proper subject.

After Herr Krizik has asserted the perfectly accurate proposition that the exertions of force of solenoids upon a cylindrical iron rod, solid or hollow, change with every change in the position of this rod with respect to the solenoids, he continues:—

"In the sequel, peculiar iron rods will be brought forward upon which, in contrast to the former, the exertions of the force of one solenoid, or of several,

remain equal almost for half the length of the rod. This new effect is produced by giving the iron rod different sections, corresponding with the variation of attraction at different points, or by combining several iron rods of different lengths or at different distances from each other to one long rod."

In the sequel, Herr Krizik shows the application of this new action in the construction of an electrical arc-light. In all his figures there appear a bi-conical core, and this has actually been carried out in the light patented and constructed by Messrs. Krizik and Piette.

My following researches prove that this alleged advantage of the bi-conical iron core, as compared with the cylindrical, is non-existent, so that it is indifferent whether we use in an electric arc-light a cylindrical or a conical core. Both act imperfectly as regulators, and it is merely due to the differential bobbin of Hefner Alteneck that a rather long extent of core can be used at all for the regulation of arc-lights. I am not speaking of divided lights, but merely of a plain, single light.

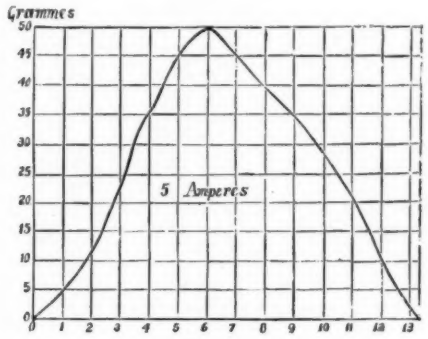


FIG. 2.

For the case of an equal length of the iron core and of the solenoid-bobbin, I gave in my memoir on "New Solenoid Galvanometers," (Central Blatt für Electrotechnik, vol. 5, p. 620), the curve of electromagnetic attraction (fig. 1), and pointed out expressly that it is the same for a bi-conical and for a cylindrical core. Recently I have extended these measurements to the particular case where the core is three times the length of the bobbin. These measurements have been made with an accurate Salter's letter-spring balance, so

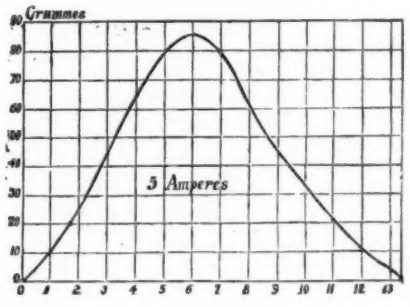


FIG. 3.

that the bobbin, traversed by the current in equable strength, is gradually moved down upon the core which is suspended and which stretches the spring, and its lifting power is read off in grammes at each centimetre. According to the tables thus constructed, the curves of attraction here following have been drawn. (Figs. 2 and 3.) The ordinates of the maximum attractions have been made almost equal in size for convenience in examination, which does not affect the proportion of the various parts of the curves to each other. Both cores were, as before, 20 centimetres long, and 1·4 centimetre in thickness. The rest will be at once understood from the diagrams.—*Central Blatt für Elektrotechnik.*

A SYSTEM OF UNDERGROUND CONDUCTORS.

THE system which is the subject of the following description, is given at length in the report of the American Sub-Committee on electrical and mechanical devices which has recently been issued. Amongst the names of the gentlemen composing the committee, we notice those of Professors Henry Morton and Elihu Thomson. These gentlemen, together with their colleagues, mention particularly a system of conductors where several direct wires are provided with a common return wire, both the direct and return wires being wound in long spirals on a core of any material, so that the direct and return wires always occupy the same relative position to any external wire. Quoting from the report:—

"A modified construction consists in laying the wires parallel and braiding or twisting them at intervals. Each of the several direct and their common return are thus arranged to be equidistant from any neighbouring conductor. Each cable is, therefore, inductively independent of all adjacent cables. While inductive disturbance may be largely eliminated, there would be—when used for telephone service—some disturbance due to branch currents. This disturbance occurs only when two or more direct wires of the same cable are in use. When but one wire of a cable is in use, the presence of the branch currents in the other unused direct wires of the same cable is evidently immaterial. When the instruments on two lines are in use—in a cable of three direct wires to one return, the length of each direct wire being one mile—the disturbance is that produced by a branch current $\frac{1}{15}$ to $\frac{1}{16}$ as strong as the current on the other wire in use. The shorter the wire, the less the disturbance. This current may be that of the transmitter, *i.e.*, the speaking current, or that of the calling instrument, the latter of which would create the greater disturbance. If all three wires are in use simultaneously (which would occur very rarely) the disturbance equals that produced by about $\frac{1}{14}$ of the current on the other wires in use. In case of eavesdropping, where on one line both instruments are in use, while on each of the two remaining lines only one is in circuit, each of the two last-named circuits will get about $\frac{1}{10}$ of a speaking current. With four miles of wire, the disturbance—if two wires are in use—would be that produced by about $\frac{1}{8}$ of the current on the other wire in use. If, on long lines, instruments of greater resistance are used, which would seem desirable, the disturbance will be less than that just stated.

"It is evident that these figures are substantially correct, it being remembered that—when the instruments are in the circuit—the resistance of the return wire is proportionately very much less than that of the direct. The greater the number of instruments or lines in use, the less the number of low-resistance paths for the return current, consequently there is an increased amount of branch current to be carried by the high-resistance wires, *i.e.*, those on which the instruments are in use, and, therefore, increased disturbance.

"This system of one common return for several direct wires does not require, in its application to the telephone service, any change in existing switch-boards. The return wires of all the cables are connected together at the central office, and operate precisely as does the present ground return, except that by causing the current to return through the conduit the effect of induction is counteracted.

"If two suburbs are to be connected, each having the ordinary ground return, they could not communicate with each other through the city central office without being subject to induction, unless some further provision be made. Such further provision might be a telephone repeater at the central office, or at any point in the line, or a simple induction coil placed anywhere in the line. The effect of such an instrument would be to divide the circuit into two circuits, the current in each of the latter being compelled to return the way it came.

"In the use of the switch-board, if the instruments of subscribers to be connected are on wires having the same common return, their respective wires will be connected without the use of the common return. If, however, the instruments of subscribers to be connected are on wires in different cables, *i.e.*, have not the same common return, the current must pass through the common return, as well as through the direct wire of each cable. This is made possible—without making any more connections than is now necessary—by the return wires of all the cables being always connected with each other.

"This system of one common return for several direct wires might also be used for the telegraph service with the duplex, quadruplex, and automatic, as well as with the ordinary Morse instruments. The grounded wire would merely be extended parallel with the direct wires and grounded outside the area of inductive disturbance. No change in instruments or connections would be necessary. In a modification of the system just described, it is proposed to use cables for telegraph service, each of which is used as a single or grounded circuit, and to arrange these cables inductively independent of the light wires. This is accomplished as follows. The positive and negative light wires are arranged on opposite sides of the conduit. Those telegraph cables which lie in the median plane or equidistant from the positive and negative light conductors, are given a half twist at the connection boxes if not already sufficiently twisted, so that each wire of the cable is alternately on opposite sides of the exact median plane. Those cables which do not lie in the median plane are crossed at the connection boxes from one side to the other of the

median plane, and also given a half twist, so as to lie for equal distances in equal proximity to the positive and negative light conductors, by which arrangement the telegraph wires are rendered inductively independent of the light wires.

"The telegraph wires are not rendered inductively independent of each other by this arrangement, but this, though an objection, is not a serious one.

"For the telephone service, the anti-inductive system of one common return for several direct wires is to be used, and, preferably, three direct wires are allotted to one return, and the four made into a cable.

"Briefly stated, this plan is as follows:—

"1. Positive and negative light conductors arranged, respectively, on opposite sides of the conduit.

"2. Telegraph wires used in single circuit, arranged in cables and rendered inductively independent of the light wires by the system of crossing before described.

"3. The fire department telegraph, which may not in all cases desire to use a metallic circuit, and the burglar alarm, to have their wires placed centrally in the conduit. The Automatic Signal Telegraph Company's wires, by reason of the peculiar arrangement of the circuits, may also be centrally placed.

"4. Telephone wires arranged in cables and one return provided for several direct, as before described. District telegraph wires (messenger service) to be provided with common return cables, as proposed for the telephone service.

"In this plan the telegraph wires are not inductively independent of each other, but inductive effects may be to a great extent lessened by a relative change of position of the wires at intervals, so that a wire which lies for a distance in proximity to one wire or series of wires, changes its position to lie in proximity for another distance to a different wire and series of wires, and so on.

"The shorter the distance any two wires lie parallel to each other, the less the inductive disturbance, and, generally, the greater the number of wires which in turn lie parallel to one and the same wire, the less probability of interference from induction, for some may not be in use, or the current in some may be in an opposite direction to that of others. In the latter case the inductive effect of one would be lessened or neutralised by that of the other. This exchange of lineal positions of wires in a cable can be effected at the junction or connection boxes, and need not be done at every such box.

"If the disturbance from branch currents is so little that it can be disregarded, the system of one common return for several direct wires is practically as efficient as the usual metallic circuit system, while it is considerably cheaper, and is for these reasons to be preferred.

"However correct these theories may be, it would be impossible, without careful practical tests, to say positively whether such systems would meet the requirements of actual working."

IMPROVEMENTS IN THE DISTRIBUTION OF ELECTRICITY.

THIS is an invention of Mr. J. S. Beeman, and relates to certain arrangements and appliances for distributing and translating electricity.

The inventor takes two or more batteries or sets of batteries, which may consist of thermopiles, primary or secondary batteries, dynamo or magneto-electric machines, &c., and so arranged or constructed as to produce currents preferably of equal or nearly equal electromotive force, and equal or nearly equal volume or quantity by their being fitted, when necessary, with any well-known means whereby the production of current and the production of electromotive force are regulated, either or both, according to requirements.

It is not, however, in all cases necessary to the invention that the electromotive force of each of the batteries should be equal or nearly equal, although this would be generally more economical or convenient.

Neither is it in all cases necessary that the current produced by the batteries should be equal or nearly equal; and the inventor does not limit himself to the use of any form of dynamo, either series, shunt, separately excited, or compound wound, as all or a suitable combination may be used under different circumstances, but he only employs those producing continuous currents.

The + conductor from the first battery is taken by a convenient route towards the second battery and alongside and parallel to the — conductor of the second battery, and the + conductor of the second battery is taken by a convenient route towards the third battery and alongside and parallel to the — conductor of the third battery, and the + conductor of the third battery is carried in the same manner to the next, and this arrangement is continued until the + conductor of the last battery proceeds towards the first battery and alongside and parallel to the — conductor of the first battery.

When the conductors are in parallel, the external circuit of adjacent or following batteries is completed by interposing resistances, automatic or otherwise, lamps, motors, or any other suitable translating device or devices alone, or in combination with resistances, automatic or otherwise, either in multiple arc or multiple series, or any convenient combination between the + conductor of the one battery and the — conductor of the following battery.

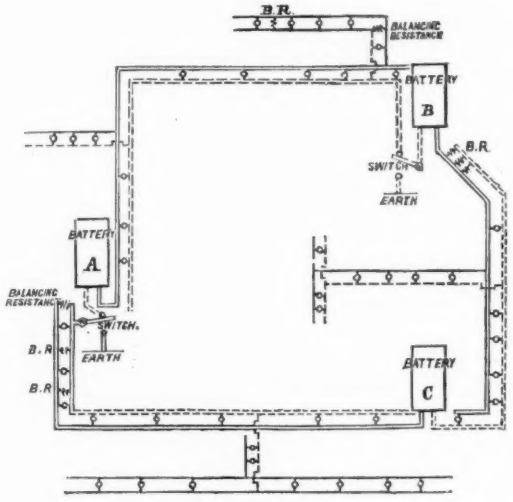


FIG. 1.

When convenient, the inventor uses branches and sub-branches connected in the ordinary way, as shown in fig. 1.

In the application to electric railways, &c., fig. 2, the + and — conductors are utilised as the rails upon which the motors or engines run, but the inventor does not limit himself to this method, as the invention

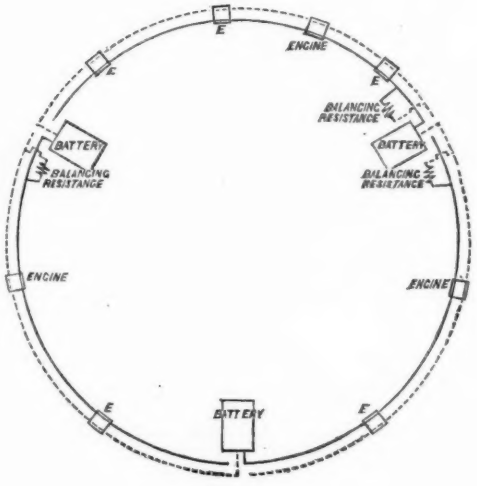


FIG. 2.

would be equally applicable to independent conductors supplying the current to the engines through the agency of a sliding or rolling contact.

Modifications are shown of the arrangement of conductors for engines or trains. In several arrangements a special means or a length of rail, not connected electrically with the general parallel, must be introduced

at each battery station, so as to prevent short circuiting when a train passes from one parallel on to the next.

The invention is also applicable to an arrangement of circuits having a compensating central conductor, X, Y, Z, batteries in series, translating devices in multiple series and balancing adjustable resistances as hereafter described, also in multiple series, as shown in fig. 3.

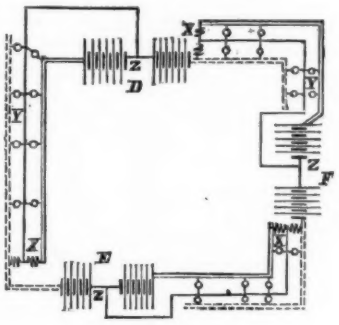


FIG. 3.

By means of these balancing resistances the electromotive force on all the parallels may be kept equal, notwithstanding the removal from any parallel of one or more translating devices—lamps for example. In this figure D, E, F represent secondary batteries. Secondary batteries can be used with the other combinations of circuits hereinbefore described, and all can be charged from a central station either by a separate circuit or by connecting up in a suitable way the discharging circuits.

If convenient, the portion of the external circuit between the last battery for the time being and the first battery can be completed by "earth" by putting one pole of the last battery and the opposite pole of the first battery to "earth," this would enable the inventor to continue working should any accident happen to one or more of the parallels.

It is obvious that if all resistances, lamps, motors, or other translating devices, are out of circuit between any two contiguous batteries, there will be open circuit. In that case the circuit can be completed by introducing suitable balancing resistances of the proper current-carrying capacity as hereafter described, or, when convenient, the circuit may be completed by "earth," or by the conductor or conductors, and then by any suitable means keep the work required to be produced by the batteries at the proper point.

If more lamps or other translating devices are cut out on one parallel than on another, say 14 translating devices on one parallel, and only four on the other parallel, assuming all are of equal resistance, the resistance of the latter parallel will be raised; then, by introducing suitable balancing resistances, the inventor restores the resistance of this parallel to its proper point, at the same time allowing the same amount of current to circulate therein as is required.

The purpose of the balancing resistance is to ensure that at all times the same amount of current shall be circulating in the conductors, however many or few translating devices may be in circuit, and thus to secure that at whatever position the points of derivation of motors, lamps, or other translating devices, or service lines of a consumer are situated on main conductors, the difference of potential can be kept practically constant.

Any suitable balancing resistances may be employed, and the work done in these balancing resistances may be used, when practicable, in forming or charging secondary batteries, in electro-plating, in the decomposition of chemicals, or in the production of any other useful effect according to the locality where the batteries may be situated.

When the translating devices before mentioned are in series, or other than multiple arc or multiple series, the above arrangement of conductors would be dispensed with, as the + pole of the first battery would be connected through the translating devices, in series &c., to the — pole of the second battery, and so on through the remaining batteries.

The invention is applicable to an arrangement of separate sections of the insulated conductors, having bridge pieces which establish metallic connection throughout the series of sections, so that whenever there is no train upon the line the sections are coupled together, and are thus made to form part of the circuit between one battery and the next.

Suitable forms of this arrangement of separate insulated sections and bridge pieces are shown in patents No. 1830, 1882, and No. 4548, 1882, by Prof. Fleeming Jenkin, capable of adaptation to this invention, or other kinds of bridge pieces and arrangements may be used.

At each battery one length of rail equal to the length of the train has no electrical connection with the circuit. This is to prevent the train from short circuiting the battery, but other means can be used for the same purpose.

An arrangement is shown of three separately excited dynamo-electric machines, coupled so that the field circuit of dynamo A is a translating device between the positive conductor of dynamo A and the negative conductor of dynamo B, and that the field circuit of dynamo B is a translating device between the positive conductor of dynamo B and the negative conductor of dynamo C, and so on. In this case lamps are shown as the other translating devices, also balancing resistances.

If, in such electric series systems as have been described, such a thing should occur as that no translating devices, trains for instance, should be on one parallel, then the circuit is completed either by introducing balancing resistances as before described, or metallically, and using, if necessary, suitable well known means for regulating the electromotive force and current generated by the batteries.

Should it happen that there should not be sufficient translating devices to absorb the energy generated by the batteries, then the inventor either introduces balancing resistances as required, or uses suitable means for regulating the electromotive force and current generated by the batteries.

The inventor claims the arrangement of appliances for distributing and translating electricity by means of suitable and convenient batteries in series, the circuits between them being closed by the interposition between the positive and negative conductors, or positive and negative poles of adjacent batteries of suitable and convenient resistances, alone or in combination with suitable and convenient translating devices, the translating devices being either alone or in combination with resistances, and being either in series, series multiple, multiple arc, multiple series, or any other convenient combination.

Appended is a report given on this invention by Prof. George Forbes :—

In the ordinary manner of working when the main conductors have any considerable length, and lamps, motors, or other translating devices are connected with the conductors at different parts of the conducting circuit, it is found that the potential of the electricity (analogous to gas pressure) is very much diminished at the far end of the conductors.

In consequence of this it becomes necessary when lighting in this manner to use lamps of different qualities in different parts of the circuit, those which are furthest from the source of electricity being so constructed that they require less electric potential than those near to the source. In this manner, clumsy and inconvenient though it is, a tolerably good effect can be obtained so long as the proportionate number of lamps in use in different parts of the circuit remains pretty much the same. In the case of fixed motors a similar device may be equally imperfectly attained. But with electric locomotives this cannot apply. There a motor, which is far from the source of electricity, requires as high a potential as one which is near to it, and the ordinary method of supplying the current fails.

The object of this patent is to arrange the circuits, and the generators which feed these circuits, and certain controlling apparatus in such a manner as to overcome the difficulty, so that a lamp or motor shall work for all practical purposes equally well

in any part of the circuit, and so that the same type of lamp or motor can be used throughout.

On referring to the M.S. specification I see that two or more generating stations are combined together. The generators at these stations are not connected to the main conductors in *quantity*, as is done in the method of distribution known as the network system, but they are connected *in series* to the mains, each pair of generators being separated by a district from which a supply is being drawn. To the best of my present knowledge of what has been done in the matter, this is a distinct addition to the practice of electrical distribution. In this manner the positive and negative main conductors in any section of a district are connected with separate machines at opposite ends of that section. This resembles the mode of distribution known as the line of centres distribution, which possesses one great advantage. This is, that when the mass of metal in the conductors is suitably proportioned in its different parts, and when the proportionate consumption in different parts of the circuit is the same as the normal consumption for which the mains have been designed, then the available electric potential is constant over the whole system. According to the M.S. specification before me, when the normal proportion is deviated from, balancing resistances are introduced to reduce the consumption approximately to the normal proportions.

According to this specification I notice that the same current must pass through the whole system of main conductors. If, then, in some sections the consumption is reduced, balancing resistances must be introduced in these sections to consume the superfluous current. This would be a serious disadvantage if the relative rates of consumption in different parts of the district varied enormously. On the other hand, the conductors and insulation can be used smaller than they could be it the same district were fed by one positive and one negative conductor.

This system shares the advantage of small conductors with a multiple series arrangement of lamps, but it has the advantage over it of requiring a lighter insulation for the mains, and also a greater facility of compensation when the normal consumption of electricity is deviated from.

Other inventors have generally aimed at centralisation of the generators. This is a step in the direction of decentralisation, which is advantageous in some installations, and which may in the future become very important when people have realised the size of conductors required for a direct centralised supply.

Of course it must be noticed that the balancing resistances use up energy which cannot all be utilised.

Turning now to particular cases discussed in the M.S. specification, I find the same ideas applied in a variety of different manners to the distribution of electricity for lighting, motive power, and electro-plating.

I should only be introducing confusion into my statements were I to attempt to examine in detail the merits of each proposal in this specification, but I will make a few general remarks on those which seem to me to be most interesting.

In one case there are two generating stations, one consisting of dynamo machines, the other of accumulators arranged in a special manner. If this claim be valid I think it may often be applied advantageously.

In several of the drawings there are some novel methods of connecting up the dynamos and conducting circuits, which promise well, but which must undergo the test of experience, guided by calculations before it would be safe to judge of their merits.

The distribution of electricity for electric trains or locomotives, which is indicated, has decided advantages.

The general remark I would make about the special cases referred to in this specification is that (granting the validity of the claims—a matter which I have not exhaustively examined), there is much which promises well, but without actual trials it is impossible to say which, if any, are likely to find general adoption; but the idea of using the generators in series, with intermediate translating devices, opens up a possibly very large field for industrial applications.

Some of the devices are even now worthy of being introduced as superior to others for special installations, and, to the best of my belief, some of the other devices will be found on trial to meet special difficulties in the distribution of electricity on a large scale.

(Signed) GEORGE FORBES.

34, Great George Street, Westminster,
April 24th, 1884.

A NEW FORM OF SPRING FOR ELECTRIC AND OTHER MEASURING INSTRUMENTS.*

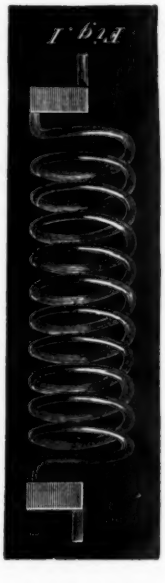
By Profs. W. E. AYRTON, F.R.S., and JOHN PERRY, M.E.

IN steam and gas engine indicators the pressure of the fluid on a piston produces a slight shortening of a spiral spring which is magnified by a lever, and so the pressure of the steam or gas is recorded. In what are usually known as spring balances there is also occasionally a magnification of the elongation of a spiral spring effected by the use of a rack and pinion. Such magnifying arrangements, however, not only introduce inaccuracy by the bad fitting of hinges or of teeth, an inaccuracy which is aggravated by wear, but they increase the cost of measuring instruments and their liability to get out of order.

And, as an example of the difficulty of using a wheel and pinion for the magnification of an angular motion produced by a small force, we may mention that although we used this plan for a year or more in our electric measuring instruments, and although the wheels and pinions were made by a good watchmaker, still the friction involved in such a plan has induced us to abandon it in favour of the new arrangement, which is the subject of this communication.

The telescopic method employed by Weber, and the spot of light method due to Sir W. Thomson for magnifying the effect of an angular motion are, of course, unequalled for stationary measuring instruments, but for instruments which must be carried about and used quickly without the necessity of adjustment, these most ingenious reflecting methods are quite unsuitable.

With an ordinary cylindric spring, having a small angle between the osculating plane and a plane perpendicular to the axis, as is the case with all spiral springs such as are in practical use, and of which fig. 1 is an example, it is well known that but very little rotation is produced between its ends by the application of an axial force. Consequently with such springs it is only possible to obtain magnification by the employment of a system of levers, or of a rack and pinion. It occurred to us, therefore, to consider whether it would not be possible to make a spiral spring of such a nature that for a comparatively small axial motion of its ends there should be considerable rotation of one end relatively to the other, and by the employment of which all levers, racks, and pinions could be dispensed with, so that no error could be introduced by wear and tear, or by want of fitting of joints, and further so that the temperature correction should be merely one affecting the rigidity of the material used as a spring, and not a correction such as has to be applied in consequence of the contractions and expansions of the various parts of an ordinary magnifying apparatus.



In order to ascertain this fact it is necessary to consider what are the general laws governing the behaviour of spiral springs. Let the centres of all cross sections of the wire, or strip, forming the spring lie on a right circular cylinder of radius, r, let the spiral have everywhere an inclination, a, to the plane perpendicular to the axis of the cylinder, and let a force, F, act at one end of the spring along the axis, the other end of the spring being fixed.

In the cross section of the wire at any point, P (fig. 2), we have, due to the axial force, F, tensile stress, whose effect in deforming the spring may be neglected in comparison with the other effects to be described, and we have the stresses produced by a couple, $F r$, acting about the axis P M. P S, P M, and P U are all in a plane tangential to the cylinder at the point, P, P M being drawn in this plane perpendicular to the axis of the cylinder, P U tangential to the spiral line, and P S perpendicular to P U.

This couple is equivalent to the couple $F r \cos a$, which is a twisting couple about the axis P U, and to $F r \sin a$, a bending couple about the axis P S. If now B is the flexural rigidity of the wire in the osculating plane, and if A is the torsional rigidity about the spiral line at P we have—

$$\frac{F r \cos a}{A}$$

as the angular twist per unit of length about the axis P U, and

$$\frac{F r \sin a}{B}$$

as the angular bending per unit of length about the axis P S.

* From the proceedings of the Royal Society, No. 230, 1884.

Resolving both of these horizontally and vertically, we have for the total angular motion in a vertical plane, that is, about the axis P M—

$$\text{F}\, r\left(\frac{\cos^2 a}{\text{A}} + \frac{\sin^2 a}{\text{B}}\right),$$

and for the angular motion in a horizontal plane—

$$\text{F}\, r \sin a \cos a\left(\frac{1}{\text{A}} - \frac{1}{\text{B}}\right).$$

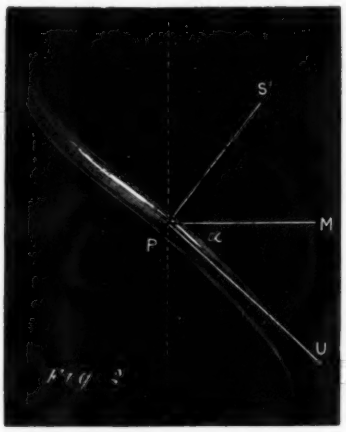


Fig. 2

If the angular motion, in a horizontal plane, of the free end of the spring relatively to the fixed end to be called ϕ, and if the axial increase of length be called d, and the whole length of the spring along the spiral l, then—

$$\phi = l\,\text{F}\, r \sin a \cos a\left(\frac{1}{\text{A}} - \frac{1}{\text{B}}\right) \qquad (1),$$

and

$$d = l\,\text{F}\, r^2\left(\frac{\cos^2 a}{\text{A}} + \frac{\sin^2 a}{\text{B}}\right) \qquad (2).$$

The theory of the strength and stiffness of the ordinary cylindric spiral spring for small angles was given, we believe for the first time, by Prof. James Thomson, in the "Cambridge and Dublin Math. Journal.," for 1848, and in "Thomson and Tait's Natural Philosophy," vol. i., §§ 588–608, the general behaviour of wires subjected to forces at their ends is investigated, and we might have obtained equations (1) and (2) from the general result of that investigation given in Article 607, but we have preferred to deduce these two equations from first principles.

The general expression worked out by M. de St. Venant for A for a prism of rectangular section involves an infinite series, and its use would give rise to mathematical expressions of an unwieldy character in an investigation like the present. We have, therefore, decided to consider our strip of which the new spring is to be made as having an elliptic section. We may mention, however, for the benefit of students, that an examination of the expression given by Thomson and Tait, "Nat. Phil.," vol. i., for the torsional rigidity of a prism of rectangular section has led us, we believe, to detect two errors in it; one is a misprint of nab^2 for nab^3, the other that the coefficient employed $\left(\frac{2}{\pi}\right)^5 \frac{b}{a}$ ought to be $\left(\frac{2}{\pi}\right)^5 \frac{2\,b}{a}$. A friend of ours who has been kind enough, at our request, to check the investigation agrees with us in thinking that there are two errors, but considers that the second is not in the coefficient, but in the fact that $\frac{1}{3}$ has been used in the formula in place of $\frac{1}{5}$. We still are of opinion, however, that the error is in the coefficient, because when we employ our two corrections, we obtain—

$$\text{A} = nab^3\left[\tfrac{1}{3} - \left(\frac{2}{\pi}\right)^5 \frac{2\,b}{a}\,\Sigma\,\frac{1}{(2i+1)^5}\,\frac{1-\epsilon^{-(2i+1)\frac{\pi a}{b}}}{1+\epsilon^{-(2i+1)\frac{\pi a}{b}}}\right]$$

where a and b are the length and breadth of the strip, and this formula we find agrees with the experimental results of M. de St. Venant, and also with the calculated numbers given in Thomson and Tait's "Natural Philosophy," § 709, for the torsional rigidity of a square shaft; whereas neither the formula for A given in Thomson and Tait's book, nor the formula as corrected by our friend, will do this.*

Reverting to the elliptic section, if the principal semi-diameters of this ellipse are b, measured in the osculating plane of the spiral, and a measured perpendicular to this plane, the values of the two rigidities are—

$$\text{A} = \frac{\text{N}\,\pi\,a^3\,b^3}{a^2+b^2}, \text{ and } \text{B} = \frac{\text{E}\,\pi\,a\,b^3}{4},$$

where N is the modulus of rigidity of the material, and E is Young's modulus.

Hence substituting, equation (1) becomes—

$$\phi = l\,\text{F}\, r \sin a \cos a\,\frac{1}{\pi\,a\,b^3}\left(\frac{a^2+b^2}{\text{N}\,a^2} - \frac{4}{\text{E}}\right) \qquad (3),$$

$$d = \frac{l\,\text{F}\, r^2}{\pi\,a\,b^3}\left(\frac{a^2+b^2}{\text{N}\,a^2}\cos^2 a + \frac{4}{\text{E}}\sin^2 a\right) \qquad (4).$$

Maximum Rotation, Positive and Negative Springs.—If we merely require that ϕ shall be a maximum for a given axial force F, independently of the stresses produced in the material, and independently of the axial elongation, then it is evident that a ought to be equal to 45°, and l and r as great as possible. If our other condition is that the area of cross section of the strip is to be a constant—

Let $a\,b = s$,

and $a = k\,b$

so that $b^2 = \frac{s}{k}$.

Then
$$\frac{1}{\pi\,a\,b^3}\left(\frac{a^2+b^2}{\text{N}\,a^2} - \frac{4}{\text{E}}\right) = \frac{1}{\pi\,k\,\frac{s^2}{k^2}}\left(\frac{k^2+1}{\text{N}\,k^2} - \frac{4}{\text{E}}\right),$$

$$= \frac{1}{\pi\,s^2}\left(\frac{k}{\text{N}} + \frac{1}{\text{N}\,k} - \frac{4\,k}{\text{E}}\right),$$

or since N is equal usually to about two fifths E, we find that

$$\phi \propto \frac{5}{k} - 3\,k.$$

Now when k is very small this is very great. On the other hand, when k is very great this is also very great, but of the opposite sign. As k increases from 0 the expression to which ϕ, or the amount of turning, is proportional diminishes until when k reaches a value nearly 1·3, ϕ becomes 0, or there is no rotation of the spring produced by an axial force. In fact, for small values of k there is a rotation of the spring in the direction of the coiling, and the amount of rotation becomes the greater the smaller k is, while for values of k greater than 1·3 there is a rotation of the spring opposite to the direction of the coiling, the rotation becoming greater the larger k is.

Fig. 3 shows a spring in which k is greater than 1·3, and it is found that there is an uncoiling on the application of an axial force. Fig. 4 shows a spring made of the same material, but the wire has been pased through rolls so as to flatten it in the opposite way, and now a rotation tending to coil it up is found to be produced by the application of an axial force.

The twisting torque to which the spring is subjected is $\text{F}\, r \cos a$, and the bending torque to $\text{F}\, r \sin a$. But the twist must be multiplied by $\sin a$, and the bend by $\cos a$ when we project these motions on a horizontal plane. So far, then, as the total rotation in a horizontal plane of the free end of the spring relatively to the fixed end is concerned, it may be regarded as being produced by equal twisting and bending torques, each of them equal to $\text{F}\, r \sin a \cos a$; and the total rotation of the free end of the spring relatively to the fixed end, which is the special feature of the springs we are considering, is proportional to the difference between the two angular rotations produced in the wire by these equal bending and twisting torques. The twist alone would cause an increase in the number of coils, that is, a rotation in the direction of coiling which is what we call positive, while the bending, or rather the unbending, alone would cause a negative rotation, or one tending to uncoil the spring. When both occur together in the actual spiral spring subjected to an axial force the total rotation is positive or negative, according as the angular twist or the angular bend is the greater. Hence the flexural and torsional rigidities of the wire alone determine whether the rotation is positive or negative.

It is well known, for example, that when a wire of circular section is subjected to equal twisting and bending torques the twist is greater than the bending for almost all substances, that is, substances in which the ratio of the modulus of rigidity to Young's modulus is between one-third and one-half. Hence we may expect that in a spring made of round wire, and with the spires making an angle of 45° with a plane perpendicular to the axis, the total rotation will be positive for an axial force applied so as to lengthen the spring. And experiment shows that this is the case.

If the wire be flattened and bent so that the flat side of the strip touches the cylinder on which the wire is coiled, as shown in fig. 3, then the arrangement is such that the bending is greater than the twist. Hence an axial force applied so as to lengthen this spring causes a negative rotation, whereas if the strip be coiled as in fig. 4, so that the edge of the strip lies against the cylinder on which it is coiled, an axial force similarly applied will now cause a positive rotation. It is almost certain that for any strip of material the positive value of ϕ obtained with the latter form of spring is likely to be greater than the corresponding negative value with the former kind, but the difficulty of manufacturing the second

* Since this paper was presented Mr. R. T. Glazebrook has been kind enough to go through the investigation, and he confirms our correction of the formula as given in Thomson and Tait's "Natural Philosophy."

form of spring, where k has a very small value, has compelled us to confine our attention to the former type.

Permanent Set.—Having constructed some very delicate springs of this kind, one of the first difficulties which we met with arose from their liability to acquire a permanent set, so that it has been necessary to determine the dimensions of the spring which will give the largest amount of rotation with the minimum amount of stress in the material.

The shear stress at any point, x, y, in an elliptic section if the prism has received a twist τ per unit length, is—

$$\text{N}\left(\tau x + \frac{d\gamma}{dy}\right) \text{ in the direction of } y,$$

and

$$\text{N}\left(-\tau y + \frac{d\gamma}{dx}\right) \text{ in the direction of } x,$$

where

$$\gamma = -\tau\frac{a^2 - b^2}{a^2 + b^2}xy,$$

where a and b are the principal semi-diameters of the ellipse, the axis of y being parallel to the semi-diameter b.

Consequently these shear stresses equal—

$$\frac{2b^2\,\text{N}\,\tau x}{a^2 + b^2} \text{ and } -\frac{2\,\text{N}\,\tau y a^2}{a^2 + b^2} \text{ respectively;}$$

and the total shear stress is equal to

$$\frac{2\,\text{N}\,\tau}{a^2 + b^2}\sqrt{b^4x^2 + a^4y^2}.$$

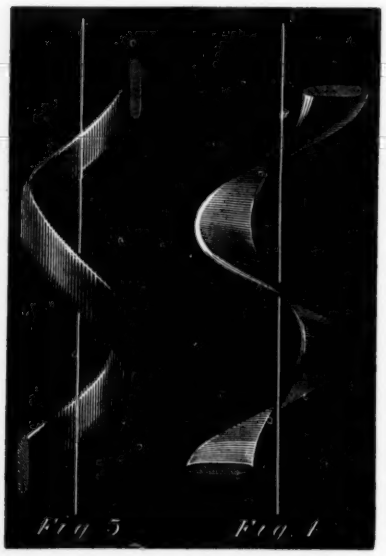


Fig. 3 Fig. 4

From this we see that the greatest shear stress is at the ends of the minor axis, and at the boundary it is the least at the ends of the major axis—

If C is the twisting couple we know that—

$$\tau = \frac{\text{C}}{\text{A}}, \text{ or}$$

$$\tau = \frac{\text{C}}{\text{N}}\frac{a^2 + b^2}{\pi a^3 b^3}.$$

Using these values of τ in the above we obtain for the total shear stress at a point, x, y, of an elliptic section—

$$\frac{2\,\text{C}}{\pi a^3 b^3}\sqrt{b^4x^2 + a^4y^2} \qquad (5),$$

and this at the extremity of the minor axis becomes

$$\frac{2\,\text{C}}{\pi a b^2}$$

Applying (5) to our case where the twisting couple is $\text{F}\,r\cos a$, and the bending couple $\text{F}\,r\sin a$, and recollecting that the direction we have chosen for y on the section is perpendicular to the axis of the spiral, we see that at a point, x, y, on the section bent about the axis of x, that is, x is perpendicular to the plane in which bending occurs the shear stress, q, equals—

$$\frac{2\,\text{F}\,r\cos a}{\pi a^3 b^3}\sqrt{b^4x^2 + a^4y^2} \qquad (6),$$

and the tensile or compressive stress, p, at the point x, y due to bending equals

$$\frac{4y}{\pi a b^3}\,\text{F}\,r\sin a \qquad (7).$$

And the resultant tensile, or compressive, stress f at the point x, y is

$$\frac{p}{2} + \sqrt{\frac{p^2}{4} + q^2},$$

Therefore since

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

is the equation of the ellipse, the stress at the boundary,

$$f = \frac{2\,\text{F}\,r}{\pi a b^3}\left(y\sin a + \sqrt{y^2 + \cos^2 a\frac{b^2}{a^2}(b^2 - y^2)}\right) \qquad (8).$$

We have now to consider for what value of y this expression is a maximum. The possible values of y are between 0 and b; and we see that if $1 - \frac{b^2}{a^2}\cos^2 a$ is positive, f will be greatest when y has its greatest possible value, namely b. For sections 1, 2, 3, 4, therefore, of the strip shown in fig. 5, where A B is the axis of the spring, the greatest stress will in each case be at B. If, however, b be very large compared with a, which is the case in the section 5, fig. 5, then f will not have its greatest value at B.

We find also that when

$$a < b\cos a,$$

f has its greatest value when

$$y = \frac{a\,b^2\sin a}{\sqrt{(b^2\cos^2 a - a^2)(b^2 - a^2)}} \qquad (9).$$

Now this value of y is greater than b so long as

$$a^2b^2\sin^2 a > (b^2\cos^2 a - a^2)(b^2 - a^2);$$

and when these are equal we have

$$a^2 = b^2(1 \pm \sin a)$$

where the positive sign is evidently inadmissible, since our condition above is that a is less than b.

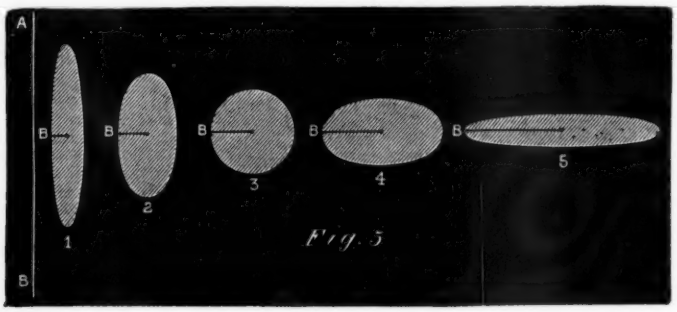


Fig. 5

Hence from b equal 0 through b equal a to b equal $\frac{a}{\sqrt{1-\sin a}}$, the greatest stress occurs at the extremity of the y axis. After that, the point of greatest stress is nearer to a, but still on the circumference of the ellipse.

Now if b is very great compared with a, then we have as a limit,

$$y = a\tan a,$$

so that the greatest stress can never occur at the end of the semi-diameter a, but may be very near to it.

On the supposition then that, relatively to a, b has any value from 0 to $\frac{a}{\sqrt{1\sin a}}$, the greatest stress in an elliptic section occurs at the end of the semi-diameter b, which is parallel to the axis of y, and this is the case we will first confine ourselves to.

Maximum Rotation in Relation to Permanent Set.—If, now, f is the greatest stress at any point of the section,

$$\frac{\phi}{f} = \tfrac{1}{3}\frac{l}{b}\frac{\sin a\cos a}{1 + \sin a}\left(\frac{a^2 + b^2}{\text{N}\,a^2} - \frac{4}{\text{E}}\right) \qquad (10).$$

The conditions that make this a maximum are those which for a given axial force applied to our spring produce the greatest amount of turning of the free end with the least amount of stress on the material, and therefore with the least chance of permanent set. And as regards the valve of a, it is clear that

$$\sin a = -\tfrac{1}{2} \pm \tfrac{1}{2}\sqrt{5},$$

or

$$a = 38°\,10',$$

will give the greatest value.

Maximum Rotation compared with Axial Motion.—From equations (3) and (4) we have

$$\frac{\phi}{d} = \frac{\tan a}{r} \times \frac{\dfrac{a^2 + b^2}{\text{N}\,a^2} - \dfrac{4}{\text{E}}}{\dfrac{a^2 + b^2}{\text{N}\,a^2} + \dfrac{4}{\text{E}}\tan^2 a} \qquad (11),$$

and the conditions that make this a maximum are those which for a given axial force applied to the spring give the greatest amount

of turning of the free end of it with the least amount of axial lengthening. As regards the value of a, it can easily be shown that $\frac{\phi}{d}$ will be a maximum when

$$\tan a = \sqrt{\frac{E}{N} \cdot \frac{a^2 + b^2}{4\,a^2}}.$$

If b is small in comparison with a, which is a condition, as already explained, we are led by facility of construction to adopt, then

$$\tan a = \tfrac{1}{2}\sqrt{\frac{E}{N}}.$$

As a rough approximation, taking N the modulus of rigidity at two-fifths of Young's modulus, the ratio given by M. St. Venant, this value of tan a becomes equal to $\sqrt{\cdot 625}$, or

$$a = 38^\circ\ 19',$$

makes $\frac{\phi}{d}$ a maximum.

We have already seen, from (3), that to merely make ϕ a maximum for a given axial force, a ought to be 45°, and l and r as great as possible.

We are therefore led from three considerations—

1. That an axial force shall produce a maximum relative rotation;
2. That the rotation shall be great without producing permanent set in the material;
3. That the rotation shall be great in comparison with the elongation of the spring;

to make the angle of the spiral about 45°.

Further, to produce the first two of these conditions, it will be observed that the length of the wire forming the spring ought to be great, while the third condition is independent of the length.

Next, with regard to the proper radius, r, to give to the coils of the spring. ϕ increases with r, $\frac{\phi}{f}$ is independent of r, and $\frac{\phi}{d}$ varies inversely as r. Hence, as the first and third conditions are antagonistic one to the other, the value of r must be chosen to suit the conditions of the instrument in which the spring is to be used; that is, we must consider in any special case whether the possibility of permanent set or a large axial motion is more to be avoided in the particular instrument in question.

Let us now consider how ϕ, $\frac{\phi}{f}$, and $\frac{\phi}{d}$ depend on a and b. Referring to equation (3), if b is not greater than a, it is clear that the smaller b is the larger ϕ will be. Next putting N equal to $\frac{2}{5}$E, an approximation sufficiently accurate for the substances likely to be employed, we see from equation (10) that $\frac{\phi}{f}$ depends on

$$-\frac{1}{b\,E}\left(1{\cdot}5 - \frac{5\,b^2}{2\,a^2}\right),$$

and as in this first case we are limited to values of b between 0 and $\frac{a}{\sqrt{1 - \sin a}}$, or between 0 and about $1{\cdot}84\,a$ if we put a equal to 45°, a value not far from that which we have already determined to be the best, then it is obvious that the smaller b is the larger will be $\frac{\phi}{f}$.

From equation (11) we see that $\frac{\phi}{f}$ depends on

$$\frac{(a^2 + b^2)\,E - 4\,N\,a^2}{(a^2 + b^2)\,E + 4\,N\,a^2};$$

or, putting N equal to $\frac{2}{5}$ E, this becomes

$$\frac{5\,\frac{b^2}{a^2} - 3}{5\,\frac{b^2}{a^2} + 13}.$$

Hence, remembering as before, that b^2 has only values between 0 and $3{\cdot}4\,a^2$, we see that the last fraction varies between $-0{\cdot}23$ and $+0{\cdot}47$.

Hence, taking b small, which gives the greatest values for ϕ and $\frac{\phi}{f}$, we obtain a value for $\frac{\phi}{d}$ not less than half as great as if we had taken the largest possible value of b.

Finally, therefore, if b varies from 0 to $\frac{a}{\sqrt{1 - \sin a}}$, the best practical value of b is an extremely small one, or the strip should be wound as in fig. 3.

If b is greater than $\frac{a}{\sqrt{1 - \sin a}}$, conditions other than those given above may make ϕ, $\frac{\phi}{f}$, and $\frac{\phi}{d}$ have their maximum values; but, since the difficulty of manufacturing metal springs of the form shown in fig. 4 must necessarily render their employment but very limited, a mathematical examination of this problem has not much practical value. We therefore merely mention that in this case calculation shows that

$$\frac{\phi}{f} = \tfrac{1}{3}\,l\,a \tan a\left(\frac{a^2 + b^2}{N\,a^2} - \frac{4}{E}\right)\frac{1}{b^2}\sqrt{\frac{b^2\cos^2 a - a^2}{b^2 - a^2}} \quad (12),$$

where f is the maximum stress anywhere in the section, the maximum stress in this case not occurring at the extremity of the b diameter.

The general conclusions therefore arrived at are, that in order, with a given axial force to obtain a large amount of turning of the free end of the spring, combined with small maximum total stress in the material, and not too much axial motion of the free end of the spring, the strip of elliptic section should be as long and as thin as possible, should be wound in a spiral such that the osculating plane makes an angle of 40° to 45° with a plane perpendicular to the axis of the spiral, and so that the smaller diameter of the elliptic section is at right angles to the axis of the spiral.

(To be continued.)

REVIEWS.

The Principles and Practice of Electric Lighting. By ALAN A. CAMPBELL SWINTON. London: Longmans, Green & Co.

The aim of the author of this work (of 172 pages) has been to write a book which should meet the wants of employers of the electric light, and the general scientific public who take an interest in all new discoveries and inventions. With one or two exceptions, everything treated is of modern interest. The book consists of 11 chapters, which, commencing with an introduction, deal with "The theory of electricity," "Electrical, mechanical, and photometrical measurements," "Sources of power," "Dynamo-electric generators," "Arc lamps," "Semi-incandescent and incandescent lamps," "Electric accumulators," "Electric lighting systems," "The electric light in its various applications; its advantages, and cost." An appendix concludes the work. Undoubtedly, Mr. Swinton's work contains matter which is not found in other productions of the kind, and taking it altogether, it is a very creditable performance. Literature of this description, however, is decidedly being overdone, and the fact that every new book of the kind has a ready sale is no proof whatever of its being required, since copies are purchased more for the sake of curiosity than anything else. In other words, those who are interested in electric lighting make a point of obtaining every new work that appears, in order to make their library complete, and on the mere chance that every additional work may afford them new and useful information.

Bibliography of Electricity and Magnetism, 1860 *to* 1883, *with Special Reference to Electro-Technics.* Compiled by C. MAY, with an index by O. SALLE, Ph.D. London: Trübner & Co., Ludgate Hill, E.C.

The compiler of this work (of 203 pages) states that he gives a full list of the works on electricity and magnetism which have appeared during the last 23 years, showing the advancement and progress of these sciences. The author, we observe, has done more than this, as he has included in his list, works which have never been published. Mistakes of this kind are, however, perhaps unavoidable; but a little care might have been exercised in spelling the names of the publishers correctly; such a well-known name as that of Messrs. "Spon," for instance, is given as "Spons." The work is undoubtedly an extremely useful one, and the author is very deserving of thanks for what must have proved a somewhat laborious task.

A Treatise on Electricity and Magnetism. By E. MASCART and J. JOUBERT. Translated by E. ATKINSON, Ph.D., F.C.S. Vol. I.—General Phenomena and Theory. London: Thos. De la Rue & Co., 110, Bunhill Row.

The names of the authors, and also of the translator, of this book, are in themselves a guarantee of the able

character of the work. The latter is based upon a course of lectures delivered by the authors in the College de France in the last few years. The treatise will comprise two parts; the first, which is principally theoretical, forms the present volume; the second, which will be more experimental in character, will be devoted to the examination of the various phenomena, the methods of measurement, and the principal applications, of electricity. The first volume is divided into three parts, the first part dealing with "Statical Electricity," the second with "Electrical Currents," and the third with "Magnetism." The general character of the work is very similar to the well known treatise on electricity and magnetism by the late Professor Clerk-Maxwell, and it is consequently of but little interest to practical electricians. For students, however, the book is of considerable use, and it appears likely to become of standard value.

BOOKS RECEIVED.

The Scientific Papers of J. P. Joule. Published by the Physical Society of London. London: Taylor and Francis, Red Lion Court, Fleet Street.

Inorganic Chemistry. By Dr. HERMANN KOLBE. Translated and edited by T. S. HUMPIDGE. London: Longmans, Green & Co.

A Pocket-Book of Electrical Rules and Tables. By J. MUNRO and A. JAMIESON. London: Charles Griffin and Company, 12, Exeter Street, Strand.

TELEPHONE LICENCES.

IN the House of Commons, on Thursday week, Mr. GRAY moved to reduce the vote by the sum of £15,566, being the amount received by the Post Office for royalties from telephone companies during 1883. The hon. member explained the working of the present law relating to telephonic communication, and contended that it was grossly unfair that the royalties to which he objected should be exacted, the Government having attempted to strike at the use of telephonic communication not in a direct way but by means of a side issue. A few years ago the Postmaster-General granted licences on the mere condition that a royalty of 10 per cent. should be paid. Suddenly he changed his policy, and said he would grant no licences unless the companies who applied for them should sell him as many instruments as he wanted to be used by him for any purpose he thought fit. But neither the parent company nor the subsidiary companies had power to do that, because if they did they would have violated their contracts, and the Postmaster-General knew that very well, for he had in black and white the terms of the contracts between the parent and the subsidiary companies. In August, 1882, the right hon. gentleman stated that the department had adopted the principle of free competition, not only between the companies themselves, but between the department and the companies. At that time the right hon. gentleman believed that another company had made improvements which evaded the patents of the United Company. But the right hon. gentleman found out his mistake, and the property of the United Company was confirmed to them. The policy of strangulation was adopted about two years ago, and not only had remonstrances been made by the companies, but deputations from various towns waited upon the right hon. gentleman in vain. The people of Plymouth did not understand why they should be refused facilities granted to Manchester, or the people of Cork why they should be refused facilities granted to Dublin. The right hon. gentleman, however, said that the towns which had been left out in the cold should be served by the Post Office or not at all. That was a position which the Postmaster-General would find to be untenable, because the public would not tolerate it. The principle upon which Parliament gave a monopoly to the Post Office was that there should be uniformity throughout the United Kingdom. While the Post Office had been working the telephone during the last two years they had only got 700 subscribers at their various telephone exchanges. For those 700 subscribers they had 5,000 telephone instruments, and so far were they from being apprehensive of the supply of instruments running short, that they had been selling them at a profit, and, further, the Post Office, by a contract entered into with the United Telephone Company, had a right to a supply of 15,000 more—that was to say, they had under their control 20,000 instruments in all. That was not protecting the public, but destroying the profits of the telephone companies, which earned those profits by making instruments and selling the use of them to subscribers. The action of the Post Office in connection with trunk lines was such as could not be approved. The conditions imposed by the department upon companies who wished to place different towns in telephonic communication by trunk lines, among which conditions was one to the effect that customers must be charged at a rate of 10s. per mile, were so exacting that subscribers could not be obtained, and the public were consequently deprived of the facilities for communications which they ought to have. It had been said that talking stations could be opened in London from which conversations could be held with subscribers at a charge of a 1d. The authorities, however, had refused to countenance the proposal, and the Postmaster-General had said that it could not be entertained even experimentally. The general policy of the Post Office seemed to be to prevent the public from receiving the advantage of telephones, of which the department had less than 400 in the whole of the United Kingdom. With reference to the acquisition of the telephones by the department, the right hon. gentleman would doubtless say that although he (Mr. Gray) had contended that it was impossible for the companies to comply with the right hon. gentleman's conditions, one company, the Newcastle Company, had already complied. That Newcastle contract was the most immoral (using the term in a political sense) of all the many immoral transactions of the department. He challenged the right hon. gentleman to take the opinion of any Judge in the land as to the morality of that contract. The policy of the department in acquiring instruments at all was of the same pettifogging character. The United Telephone Company entered into a contract with certain individuals to sell to them 20,000 instruments upon the condition that the instruments should not be used for ordinary trading purposes. A Yankee came over to this country and found, on the one hand, that the Post Office was anxious to obtain the instruments, and, on the other hand, that they were in the possession of these individuals. He constituted a sham company and bought the right of purchase from the Telephone Company and sold it to the Post Office, who obtained possession of it without the conditions which attached to it in the hands of the other individuals. He put it to the right hon. gentleman, if, in his private capacity, anything in the world would induce him to enter into such a contract. He did not intend to bring forward any specific vote, but he appealed to the right hon. gentleman, whose administration at the Post Office had been distinguished in many ways by liberality, to extend that policy of liberality to the telephone question and not to punish the public because, under a purely technical judgment, he had obtained the right of control. (Hear, hear.)

After a few remarks from Mr. Slagg, Mr. FAWCETT remarked that some very strong things had been said about the department by the hon. member for Carlow, but he should much regret if any word he said in reply was in any way taken to separate himself from the permanent officials of the department. He alone was responsible for everything that was done. All sorts of charges were brought against the officers of the department as if they had some private motive to serve, but they had no interest except the interest of the Post Office and of the public. (Hear.) He felt bound to confess that during the whole of his experience at the Post Office no question had been beset with a tithe part of the difficulties that he had had to consider in connection with the telephone question. Of course it would be idle now to enter into the old controversy as to whether Parliament acted wisely in purchasing up the telegraph companies at such an enormous price. It was not for the Postmaster-General appointed after that was an accomplished fact to express any opinion on that point. All that he had to do was to faithfully administer the Acts which Parliament had passed. He had had nothing to do with the policy of telegraph monopoly. When he first came to the Post Office he found that this question as to whether or not the telephone was an infringement of the telegraph monopoly was about to be raised or had been raised in the law courts. Nothing could be more ill-considered or unwise than for him now to say a single word as to the decision in the telephone case. It was urged before two able Judges, and argued with consummate ability on each side, and the judgment left no doubt whatever that, in the opinion of the Judges, at all events, the telephone was a distinct infringement of the telegraph monopoly for which Parliament had paid 10 millions sterling of the taxpayers' money. It was urged upon him that he should not deal harshly with the telephone exchange companies, and that he should not act on the supposition that they had been consciously acting illegally, and in the exercise of his full legal rights confiscate their property. He was urged to deal in a generous and liberal spirit with them. He had done so. He assumed that the telephone exchanges had been established *bonâ fide*, and he entered into an arrangement that enabled them to continue their business. Consequently in all those towns in which at the time of the decision telephone exchanges were established a license was granted to them on certain conditions which were agreed to between the companies and himself. The hon. member for Carlow had again and again repeated that he had been actuated by a desire to strangle the telephone companies. Nothing was further from his desire than to do anything unfair towards them. (Hear.) He was anxious that the public should obtain a supply of telephone communication either from private enterprise or from the Post Office, either as the one or the other could supply it most efficiently and on the most reasonable terms. (Hear, hear.) That had been his policy, and it was his policy at the present time. In granting this license to private companies he had, of course, been bound to take care that an arrangement should be made which would not prejudicially affect the revenue. Language was often used as if the officers of the department had some other in-

terest than that of the public. He had had to administer a monopoly, not which the Post Office had bought, for the Post Office had no money, but which had been bought with 10 millions sterling of money of the taxpayers, and he was bound to see that that large expenditure was guarded with adequate precautions. He was a trustee. Suppose a commercial man bought an invention for £100,000, and that he appointed a manager to administer it. Suppose that another patent was taken out for an invention which the Courts of law declared to be an infringement. Now, in allowing other people to use that patent, which was an infringement of the one which had been purchased for £100,000, he would refer it to the hon. member whether a manager would not be faithless and not properly careful of his trust if he did not see that the use of the second patent should only take place under conditions which would be adequate to properly safeguard the interests of the first one. That was exactly his position. He was nothing more than a trustee. His policy of granting licenses to all the towns in which telephone exchanges had been established went on until about two years ago. He was then met with another difficulty. He received numerous applications from other companies stating that if he did not extend the granting of telephone licenses to other companies, in other towns, he would be constituting a private monopoly. They said it was very well for the Government to have a monopoly, because if the Government abused that monopoly, a motion could be brought forward in the House of Commons. They said they had the Government directly under their control, and if the monopoly was not properly used it would be the fault of the people if they submitted to its misuse. He had been pressed on all sides not to allow a private monopoly to grow up and be vested in a private company, which could not be controlled in the same way. He decided about two years ago that he would, to a certain extent, change the policy which had been already adopted, and that he would no longer confine the granting of telephone exchange licenses to those towns which happened to have an exchange at the time when the legal decision was given, but that he would grant telephone exchange licenses to all towns and to all applicants under certain conditions. He had considered those conditions most carefully. He had considered the particular condition to which the hon. member had referred, and his sole object in insisting on that condition was that he thought it was of great importance that the department should have some larger control than they possessed at that time over the use of telephone instruments, in order not necessarily to interpose, but that it should have the power of interposing—not for the sake of making money, that was not the object—but if the interests of the public in telephonic communication should require such an interference. This new plan had gone on for a couple of years. After it came into operation, a decision was given in reference to certain patents which were claimed to be possessed by another company. That company had obtained a licence, and he understood the decision was hostile to the company, although he believed the case had not been finally disposed of; but, in the meantime, the company had not been able to carry on business. He was free to confess, as he had stated to the hon. member in the afternoon, that it had been shown by experience that the new condition which he thought it had been necessary in the interests of the public to impose two years ago had checked the development of private telephonic enterprise. He had not intended that this should be its effect: but having ascertained that this was its result, he had been considering for some months—it was a question beset with difficulties and complications—whether he could modify the condition in such a way as to get over the difficulty, while at the same time the interests of the public were properly safeguarded. He could only say that he was willing to repeat that promise. He did not wish unduly to extend the functions of the Post Office. He thought simply what the Post Office ought to do was to supply the deficiencies in private enterprise. But, with regard to this particular case of telegraphs and telephones, he wished to point out that the telegraph monopoly had been purchased at an enormous cost. He was bound to say that he would be guilty of faithlessness in regard to the trust reposed in him if he did not properly, as far as he could, safeguard the telegraph revenue. In safeguarding it he had been, and would continue to be, most scrupulously careful not to throw one unnecessary impediment in the way of development of private enterprise. The subject had engaged more of his attention than any other. He hoped he might be able, without giving any pledge, soon to be in a position to announce that he could see his way to propose some modification of the particular stipulations in those new telephone licenses to which the hon. member for Carlow and the hon. member for Manchester objected. In these circumstances, he thought it would be well not to continue the discussion on the present occasion. (Hear, hear.)

Mr. GRAY thanked the right hon. gentleman for his courteous reply. He had stated that he was bound to protect the public revenue; but he was amazed that no reference had been made by the right hon. gentleman to the deliberate expression of opinion by Parliament in 1878 on this subject. As far as Parliament was concerned, it expressed its desire that the department should not control the telephones. He hoped the right hon. gentleman would reconsider the extremely vexatious course which the department had taken in reference to the companies in minor matters. It was also to be hoped than the right hon. gentleman would see his way to announce his decision within some reasonably short space of time. Although he was ready to accept the assurance of the right hon. gentleman, this fact had to be considered. The private telephone companies and the Post Office, being competitors for the favour of the public, every day the right hon. gentleman delayed his decision gave to his department a most unfair advantage.

Mr. FAWCETT promised that, as far as he was concerned, there should be no unnecessary delay in coming to a decision. The particular point which, he said, had been for some time past engaging and still engaged his attention was the clause in the Telephone Exchange licenses which gave the Post Office a general user of the telephones. But what he had said on that point would not apply to the subject of trunk wires, because that question had, as he understood, been settled for the present at any rate.

The motion was then withdrawn.

NOTES.

Electric Lighting.—The Metropolitan Board of Works is advertising for tenders for the lighting by electricity of the Victoria Embankment and Waterloo Bridge during three years from the 1st of July next. The number of lamps to be lighted is 50, 40 being on the Embankment wall, extending from Westminster to Blackfriars, and 10 on Waterloo Bridge. The lamps are required to be lighted during six hours (beginning at sunset) on every day throughout the year.

An application of the electric light has, we believe, been made at the works of Messrs. Morgan & Co., of Bridge Road, Battersea. Hitherto it has been the practice to examine the interior of newly-made plumbago crucibles by the aid of a gas flame, in order to discover any flaws there may be in the material. Mr. Henry Thame (of Messrs. Thame & Co., Orbell Street, Battersea), the inventor of a new primary battery, applies the electric light to the purpose. An incandescent lamp, fitted with a small reflector behind, takes the place of the gas jet with the advantage of clearness, coolness, and convenience. It can be inserted into the depths of the crucible, and the internal surface examined at leisure. Five of these lamps were to be installed, fed by the "chlorochrome" battery, as devised and arranged by the inventor. This battery is said to be remarkably durable in its action, and able to keep the lamps going consecutively for 48 hours, if need be, without recharging.

The Town Council of Hanley has it in contemplation to light the borough by electricity, and is in correspondence with the Hammond Electric Light and Power Supply Company, Limited, with reference to the project.

Electric Lighting v. Gas.—A correspondent has sent us a cutting from the *Manchester Guardian* of the 23rd inst., in which is a bold advertisement from a Leeds electric light contractor to the following effect: "Crompton system, arc and incandescent, has been proved to cost not more than one third the price of gas, both for commercial and private purposes: cool, beautiful and healthy. Apply for estimates and references," &c.

Licenses for Telephone Exchanges.—In the House of Commons last week Mr. Fawcett, replying to Mr. Gray, stated that the number of applications for these licenses had been 77, and the number granted had been eight. As bearing on that subject he might state that the condition requiring each company receiving a license to undertake to sell instruments to him was solely to protect the public, and was never intended to restrict the establishment of telephone exchanges. He had been considering whether, with due regard to the public interest, that condition could be modified, and as soon as he was in a position to announce the decision it would be made known.

Telegraphy in Ceylon.—The erection of the telegraph line on the railway to Hatton, Ceylon, was, at the dispatch of the mail, being pushed forward as rapidly as possible, so that there might be no delay in the opening of the railway on the contract date, May 20th.

Cable Items.—The Spanish National Telegraph Company has removed its headquarters from Teneriffe to Cadiz, and has also, we understand, arranged for the laying of a cable from the Canaries to Puerto-Rico.

Another Atlantic Cable.—We hear that there are rumours of another Atlantic cable being laid between England and Canada. The cable would start from Thurso, in Scotland, touching at the Faroe Islands, Iceland, the West Coast of Greenland, and from there, running in a southerly direction, as far as the Bay of St. Lawrence, it will land in Gaspe Harbour. The total length of these cables would be some 3,150 N. miles; whilst the longest section would not exceed 900 miles. It is believed that, on this account, the working capacity of the proposed cable will be about double that of any of the present cables.

The Java-Sumatra Cable.—The cable between Anjer (Java) and Telok-Betong (Sumatra), which was destroyed during the volcanic eruption of Krakatoa on the 27th August, last year, was replaced some time ago by a new cable, laid between Merak (Java) and Kalianda (Sumatra). The telegraph station at Anjer, which was also destroyed during that earthquake, has now been replaced by a station, erected a little more to the North, and close to Merak Point; whilst the new station at Kalianda is situated at the landing place of the cable on Sumatra, and is connected with Telok-Betong by means of a land line.

Duplicating the Communication with Tonquin.—We read the following in *La Lumière Electrique*, of the 10th inst:—The s.s. *Sherard Osborne*, belonging to the Eastern Extension Telegraph Company, has just finished the preparatory work to the laying of the cable between Haiphong (Tonquin) and Hong-Kong, which according to the contracts of the 29th November last with the French Government, will establish a second line of communication with Tonquin. The shore end cable has already been laid from the Peninsula of Do Son (Tonquin) as far as the deep water line; and the river cable to connect Haiphong has also been laid. At the Hong-Kong end, the cable has been laid from the landing place as far as the entrance to the Straits of Hainan, where soundings have been taken to determine the course to be followed during the laying. To complete the communication, there still remains to be laid a length of two hundred and twenty miles of cable, which the *Sherard Osborne* will have to ship at Singapore. The cable will be direct, without touching at the Island of Hainan. It will be completed and open to the telegraph service in the beginning of June.

Western Brazilian Telegraph Company's Cables.—The s.s. *Dacia*, Captain W. A. Tindall, left the River Thames on the 21st inst., *en route* for Pernambuco, with a cargo of some 480 miles of telegraph cable, made at the Silvertown Telegraph Works for the Western and Brazilian Telegraph Company. Part of this cable, we hear, will be laid by the *Dacia*; the rest being transferred to the s.s. *Norseman* and s.s. *Viking*, the repairing vessels of the Western Brazilian Company.

The Mackay-Bennett Cable.—A *Times* telegram from Philadelphia, May 28th, states:—"The steamer *Faraday*, having completed laying the shore section of the new Mackay-Bennett Atlantic cable between Dover Bay, Nova Scotia, and Rockport, Massachusetts, has gone to pick up the buoyed end of the deep-sea section 70 miles east of Dover Bay. She will then lay about 1,000 miles towards Ireland all she has aboard, and then buoy the cable, afterwards sailing to Woolwich for another cargo of cable to complete the deep-sea section. The latter part of the cable is to be laid westward from Valentia."

Personal.—On Wednesday, according to the *Daily News* correspondent, the Academy of Sciences at Vienna named as honorary members Sir William Thomson and Prof. Edward Frankland.

Royal Institution.—The following change has been made in the arrangements for the Friday evening meetings:—June 6, Mr. Willoughby Smith on "Experiments in connection with volta-electric and magneto-electric induction.

Death of a Manufacturer of India Rubber.—Mr. John Hancock, who was one of the first and most active manufacturers in the development of the India rubber industry, is dead.

Silvering Incandescence Lamp Globes.—Mr. Armand Levy, of Goswell Road, writes to us—in reference to our "Notes" of last week—to the effect that he silvered the first samples of Lane-Fox lamps, Mr. Lane-Fox having intended to use silver as a reflector.

The Brighton Electric Railway.—Mr. Magnus Volk has forwarded to us the following particulars respecting his electric railway, which is about a mile in length, extending from the Aquarium to Kemp Town, and passing under the Chain Pier. This necessitates some heavy gradients, as may be seen by the following data:—1 in 100 for 230 yards, 1 in 45 for 100 yards, 1 in 16 for 50 yards, 1 in 30 for 50 yards, 1 in 150 for 200 yards. The remainder of the distance is practically level. The current is generated by a Siemens D^2 machine, driven by a Crossley 8 H.P. gas engine, consuming about 1,600 cubic feet per day of 11 hours. The cars are driven by a Siemens D^2 motor (old form), and run at a speed of 8 miles per hour. They are fitted with an internal pulley, which revolves at the same speed as the axle on the level and all the gradients except the 1 in 16, when, by means of a clutch, the gearing comes into action, which trebles the power applied to the axle with a corresponding decrease of speed. The brake power of the motor on the level is about $1\frac{3}{4}$ H.P. The financial results are also encouraging, as the following table of the last eight weeks' work will show:—

No. of passengers			34,000
Gross earnings			£278 14 3
Earnings per week, say			£34 15 0
Expenses as enumerated below			17 19 0
			£16 16 0

WEEKLY EXPENSES.

Driver	£1 4 0		
Conductor	1 4 0		
Station clerk	1 4 0		
" " female	0 6 0		
Lineman	1 1 0		
Labourer	0 18 0		
Engine driver, lad	0 12 0		
Electrical and general management	3 10 0		
		£9 19 0	
Rent of arch		0 10 0	
Repairs, say		1 0 0	
Cost of gas at 3s. 3d. per 1,000		1 10 0	
Depreciation and interest on £2,500		5 0 0	
		£17 19 0	

The above result is with one car running about 82 miles per day, say 500 miles weekly, and seating 30 passengers; two cars will shortly be running, a turn out being provided half way, and the expenses, owing to the second car being worked, will be but slightly increased, the earning capacity at the same time being doubled.

Trial of an Electric Launch.—One of Clarke's patent electric launches was tried last week on the Forth and Clyde Canal. The launch is 25 feet long by 4 feet 10 inches beam, and weighs complete, with batteries charged, about $7\frac{1}{2}$ cwt., being driven by a patent propeller 15 inches diameter. During the trial a speed of between five and six miles per hour was maintained, while the motor worked noiselessly and without vibration, developing 2·6 H.-P. This boat is the first of a fleet being built to the order of a Munich Company,

who have obtained a monopoly from the Prussian Government for several of the neighbouring lakes, and the trial proved very satisfactory, showing that considerable improvement had been made in these launches since their introduction last year.

Lightning Rods Required.—A disastrous thunderstorm visited Warrenpoint district on Wednesday week, destroying a portion of Kilowen Catholic Church, breaking the telegraph lines, and killing sheep.

The City and Guilds of London Institute.—Recently we announced that Dr. Lodge, Professor of Physics at Liverpool, had been elected to the Chief Professorship of Physics at the Central Institution of the City and Guilds of London Institute, the building for which is just completed at Kensington. We now learn that he has finally decided to remain at Liverpool, and that Prof. Ayrton, who was not previously a candidate, as he considered his professional engagements would make it impossible for him to hold the post, has been induced, on reconsideration, to accept it, and consequently has been formally appointed to the professorship. Professor Ayrton is to be congratulated on thus starting the Physical Department at the first Technical University established in England.

South African Brush Electric Light and Power Company, Limited.—A petition to confirm a resolution reducing the capital of this company from £100,000 to £50,000, has been presented to Her Majesty's High Court of Justice, and is now pending. The list of creditors is to be made out as for August 5th.

Crossed Wires.—The crossing of telegraph and telephone wires with the police and fire alarm wires in Philadelphia has led to a general order in that city requiring all the companies to remove their lines so as to leave them at least 4 feet above those of the city's own plant, on pain of having them cut.

The Action of Solenoids.—In our columns this week we publish an article by Dr. Bottcher, in which he shows that that the biconical core of the solenoid of a well-known arc lamp has no advantage over the ordinary cylindrical shape.

Incandescence Lamps.—Mr. Henry F. Joel, C.E., of Tower Chambers, Moorgate Street, writes to us, too late for our correspondence columns, as follows:—"In Mr. Probert's lecture on 'Primary voltaic batteries,' delivered before the Society of Arts, on the evening of May 28, the subject of incandescence electric lamps was introduced, and Mr. Preece, the chairman at the meeting, particularly praised the Woodhouse and Rawson lamps as being the first in which progress had been made in economy. I would point out that the incandescence lamps made by the Pilsen Company, tests of which you published in the ELECTRICAL REVIEW for May 19 and June 9, 1883, then showed as good a result as that now claimed by Messrs. Woodhouse and Rawson. It is but fair to add that the very great merit of having reduced the power required for a 20 candle power incandescence lamp, viz., from about 80 watts to 50 watts, was due to Mr. A. R. Margary, who, at the time the tests to which I refer were made, had charge of the manufacture of the incandescence lamps in the Pilsen Company's factory at Kentish Town."

Companies' Shares.—At the weekly sale of the Stock and Share Auction and Advance Company, Limited, on Thursday, Edison's Indian and Colonial Electric Company's £5 shares (£2 10s. paid) sold at 8s. 6d. each; one share only of the Spanish National Submarine Telegraph Company was disposed of at £6 17s. 6d.; Electric News Telegraph Company's shares fetched 25s.; Oriental Telephone Company's, 5s. 6d.; and the Consolidated Telephone Construction and Maintenance Company's, 4s.

NEW COMPANIES REGISTERED.

Brixton District Electric Light Supply Company, Limited.—Capital £20,000 in £5 shares. Objects:—To take over the electric lighting business carried on by Mr. Alexander Leslie Fyfe at the Fyfe Main Electric Works, Brixton. Signatories (with one share each)—J. Edmund Yates, 114, Acre Lane, Brixton; J. E. Gill, 16, Penton Place, Kennington; J. L. Mills, Leytonstone; L. F. Bruerges, 19, Arme Road, South Hackney; G. J. Ottley, 45, Windsor Terrace, City Road; R. Bryce, Cleveland Road, Islington; J. J. Parry, 3, Holly Mount, Hampstead. Registered 28th inst. by Messrs. Want & Harston, 34, Clement's Lane.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Northern District Telephone Company, Limited.—The return of this company, made up to the 12th inst., was filed on the 19th inst. The nominal capital is £100,000 divided into 2,500 preference shares of £10 each, 15,000 ordinary shares of £5 each, the latter of which are issued as fully paid. 1,088 preference shares have been issued, and the full amount has been called thereon, the calls paid amounting to £10,563, leaving £317 unpaid. Since the last return was filed, 251 preference shares have been issued, and the paid-up capital has been increased by the sum of £3,951 4s. 3d. Registered office, 13, Exchange Buildings, Quayside, Newcastle-on-Tyne.

Jarman Electrical Company, Limited.—An agreement, dated 22nd inst., was filed on the 23rd inst., authorising the allotment to Mr. Alfred James Jarman of 900 fully-paid shares, as part of the sum of £6,000 agreed to be paid to him for the purchase of the patents and other property taken over by the company.

Electrical Association, Limited.—The annual return of this company, made up to the 30th of August, 1883, was filed on the 20th inst. The nominal capital is £50,000 in 100 shares of £500 each. The whole of the shares have been allotted and £62 10s. per share has been called and paid, the calls paid amounting to £6,250. As compared with the previous return, filed on the 29th August, 1882, this return shows a decrease of £3,750 in paid up capital, it being stated in the former that £125 per share had been called upon the 100 shares, the calls paid amounting to £10,000 and unpaid to £2,500; the registered documents, however, do not supply any information explanatory of this decrease. Registered office, 1, Hatton Court, Threadneedle Street.

Electric Portable Battery and Gas Igniting Company, Limited.—The office of this company is now situate at Clegg's Court, Chapel Street, Salford, Manchester.

CITY NOTES, REPORTS, MEETINGS, &c.

Consolidated Telephone Construction and Maintenance Company, Limited.

THE third general meeting of the company was held at Cannon Street Hotel, on Friday, at which a large number of shareholders was present, and at which Colonel Gouraud presided.

The Secretary, Mr. Charles Curtoys, having read the notice convening the meeting, and the minutes of the previous meeting having been read and confirmed,

The Chairman expressed his regret for the absence of Sir Julius Vogel, chairman of the company, who was subsequently stated to be in Australia. He then said the first thing that would strike the shareholders, after such reference as was necessary to the accounts of the company, was the statement in paragraph 4 of the report, that although the financial results were far from satisfactory, they were due to causes beyond the control of the board. He would, as briefly as possible, show them the two principal causes of those results. With reference to the Postmaster-General's

contract, it perhaps required a little explanation beyond that given in the report. Those shareholders who were thoroughly acquainted with the position of the company with reference to its contracts, knew that the company stood in a peculiar position at the time of its formation. At that time the United Telephone Company was supposed, and rightly so, to be the owners of the master-patents controlling the use of the telephone, but the Postmaster-General, with the view of protecting the interests of the Government under the Telegraph Act, acquired the right to use a large number of telephones made under the patents of the United Company, or a modification—one of an infinite variety that might be made—of those patents. It was thought by some persons to be independent of them, and no doubt the Postmaster-General thought so; but what the shareholders of this company had presented to them was, that the Postmaster-General had made a contract which, by its terms as to payment for the instruments and the number to be paid for, implied a very large business. On the other hand, this company at the same time acquired the exclusive right of manufacture from the United Telephone Company of all the instruments they might require. The effect of that combination was that it would appear, and rightly so, he thought, that this company stood in the position of being reasonably certain that it would have the business of manufacturing the whole of the telephones used in this country or made for export, the latter provision being also contemplated in the arrangement with the United Telephone Company. The business was started, and it seemed impossible to meet the demand for telephones in the early operations of the company. They were pushed on the right hand and on the left, by the Postmaster-General and by the United Telephone Company, and very soon they found that their premises were altogether inadequate for the business required of them, so that they were speedily required to change to very much larger quarters. During the first period of the company's existence, therefore, the manufacturing business was very large, so large that in the last report it was stated that the results were that the profits derived, altogether apart from the business of the Telephone Company, were sufficient to enable them to pay substantial dividends upon the capital of the company. There suddenly came a check in the business, and instead of being pressed to deliver beyond the capacity of a manufacturing company so young and engaged in so new a pursuit, there were comparatively no orders—scarcely any from the Post Office, and a little later none at all, whilst orders from the United Telephone Company were surprisingly small. That state of things continued for a long time; it was still continuing, unfortunately, and they naturally wanted to know why this was, how it was possible that this could be the case, for unless they could find a good reason for it, they would not be satisfied. They must try and put the responsibility on shoulders where it belonged, more particularly if it belonged to the management of the company. They saw a certain development in different parts of the country, and asked if this was in keeping with the development in other parts of the world. They found it was not so, and that it was wholly and surprisingly out of proportion. He had in his hands extracts from the records of the United Telephone Company, of which he was a director, and he would read them some of the figures. They found in the United Kingdom what at first sight seemed an imposing number of exchange subscribers, 10,507, in a country with a population of over 40 millions, and certainly the most intelligent and enterprising people in the world. The private wires were about 2,000; there were 72 exchanges. The Post Office had 25 exchanges opened in competition with the United company, and its subscribers numbered about 700. He would quote now from the last official publication, dated October of last year, to show whether the telephone in this country had developed relatively to its extension in America. Taking 94 exchanges in America, located in commercial centres whose aggregate population was 6,500,000, there were 35,360 subscribers, a ratio of one subscriber for every 188 persons. A rough calculation showed that in London alone, had the development been relative, they ought to have about 20,000 subscribers, whereas there were only about 4,000. This state of things was vital to this company, and they must look for the cause of it. He thought they had put their finger upon that cause. It was stated in the report that it was due chiefly to the restrictions imposed upon the development of the enterprise by the Government. Of course, he knew that the Postmaster-General was primarily responsible, so far as they were concerned, upon questions affecting the telephone companies, but he was very far from desiring to make hostile remarks, for he did not know how far he might be governed by his superiors. What they knew was, that the results of the operations of the law, as decided by the courts when the companies concluded to admit, from motives of policy rather than from conviction that it was right, that their enterprise was within the Postmaster-General's monopoly, were that the companies were subject to the control of the Government, and that control had been exercised in one vital respect with a result that they saw in the figures before them, and that was the limit of the operations of the companies' exchanges to the narrow radius of five miles from the centres; nothing else could explain it. The same restrictions did not exist in any other country, except those who took the lead from England, namely, the British colonies, and notably India. It was not for him to say whether the views of the Post Office or of the companies were right or wrong, but that must be taken as the reason for the restricted development of this enterprise in this country; no one could gainsay it, and he wanted no better authority for the statements he had made than the Postmaster-General's own remarks made in the House of Commons the previous night.

During the last two years negotiations had been going on almost daily for extending this business by connecting the towns together; proposals had been made by the telephone companies, and counter proposals were brought forward by the Postmaster-General. The former, in spite of the arguments of the Postmaster-General and all his officials had stood their ground; they would not accept licenses that were prohibitive, or that would involve large outlays of capital without a prospect of return. The result of their stand was, that Mr. Fawcett stated that he had at length concluded that his policy upon that point was wrong, and he would take an early opportunity of giving a decision upon it. Of equal importance was the question of the character of the licenses insisted on if any more were required. The granting of further licenses was dependent on an agreement to sell to the Postmaster-General any telephones which he might require, and the right to buy any or all telephones such as in his discretion he might think wise from the companies expecting those licenses; it was insisted, further, that he should have the right to lease or sell the telephones. This was a great encouragement to the infringement of patents, and if theirs and the United Company's patents were infringed in that way, they would be in no better position than any ordinary manufacturer. No predictions were made in the report as to the future; they did not feel called upon to prophesy but they had determined to give the shareholders all the facts. But from what was foreshadowed in the Postmaster-General's remarks it might be that a reconsideration would lead to a result so liberal in the interests of the public that it would give fair-play to the telephone, and if it did, as the United Company was bound in its contracts with this company to defend the patents, and it was doing so now with unprecedented success, having lost not a single action thus far, if, therefore, they had a free policy, as seemed to be indicated, this company must have a large business, and, if conducted properly, ought to make money. This company paid an enormous sum, a large per centage of £175,500 to do that which they were seeking to do; it was not unreasonable to say that £100,000 was paid for the Postmaster-General's contract, which was apparently to take 20,000 telephones. The other business of the company was the export of telephones; they had a number of Gower-Bell telephones to dispose of, and it was their policy to further those interests as far as possible. But they had not a large working capital, having only a little over £50,000 left; the company undertook enterprises which they expected to relieve them, but they soon went into undertakings too large for the capital they had. They would remember that about a year ago, in order to meet this deficiency a further issue of capital to the public was made, but a sufficient amount was not raised to support the enterprises taken. With regard to the Austrian business, at the last general meeting of the company, the chairman made certain statements with regard to the position at that time; he stated that the financial embarassments of the company were relieved. They were relieved in so far as the capital coming from the new issue sufficed, but it was only a temporary relief, for the business it did in Austria was the same as in the United Kingdom. He (Col. Gouraud) was not on the board at that time, but he thoroughly knew the views of the directors with regard to the subject; it was thought that a little money might be expended in starting a business which could then be handed over to a separate company to be formed for the purpose. The times for getting capital, however, were not favourable, and the result was that the enterprise was still on the hands of the company. He went to Austria last summer and spent nearly six weeks there, with the result that he succeeded, by taking very strong grounds with the vendors in two things, in improving the position of the company; he actually limited what was before an unlimited liability. The liability at that time was of a character that might have ruined this company, and there was no way out of it except to take a stand which he felt almost ashamed to take; but he did the best he could, and made the best bargain he could, limiting the liability so that they knew now where they were with respect to that. The embarassments in Austria were only because of the want of capital; the business, he believed, was a very good one, being a practically exclusive concession. Perhaps the most important feature in the report was the item in connection with the River Plate Telephone Company. That was a business which the company became committed to when he (Col. Gouraud) was not on its board; but it was, in one sense, the most fortunate thing which this company had done. It committed itself to an enterprise on the River Plate of great promise, involving not a large amount of original outlay, and it was expected at the time of the commencement of the undertaking that the public would subscribe money with which to carry it on. This was not unnatural, as at that time a great deal of money was offering for electrical movements; but unfortunately the company did not come out until the latter part of the ebb-tide, and the money contributed was of small amount. But the business was so good that the Consolidated Company supported the new company; subsequently an attempt was made to issue fresh capital, but this met with but small response. When the Postmaster-General and the United Telephone Company almost failed them, the River Plate Company practically kept their factory going. The business was almost unique, the number of telephones in use in the River Plate territory being higher in proportion to the population than in any other part of the world. The only other outside enterprise which the company took was that in Portugal. The Edison and Gower-Bell Company in Lisbon and Oporto was doing a paying business, the exchanges numbering several hundreds, whilst the king was anxious to have Lisbon and Oporto connected; a letter he had in

his hand stated that a trial in this matter had been made a few days previously. The board was now, by reason of the absence of the chairman and the retirement of one the directors, at its minimum, and it would be the duty of the shareholders to elect new directors. Three names had been handed to him of gentlemen it was proposed to nominate, and, although he did not know either of those gentlemen, the number of shares they held, and therefore the extent of the interest they had in the company, was almost sufficient to qualify them for the board. The chairman then proceeded to remark with respect to the settlement with the River Plate Telephone Company that the board had received a protest signed by several shareholders demurring to that settlement, pointing out that in their opinion the powers of the directors were not adequate, that they had not the power to do what they had done, and, therefore, that the act was *ultra vires*. An extraordinary general meeting was called to be held at the conclusion of the general meeting to discuss that matter, and he would suggest that they passed the report subject to the carrying of the resolution that was to be proposed at the extraordinary meeting.

The Chairman having moved the adoption of the report,

Mr. Stoop moved as an amendment "That a committee of shareholders be appointed to investigate and report upon the position and affairs of the company, with full power to call for and inspect all books, contracts, agreements, accounts, papers and documents, belonging to the company; and that the consideration of the report of the directors be adjourned until after the receipt of the report of such committee; and that Messrs. H. Grewing, A. Baker, C. L. W. Fitzgerald, J. Taylor, and G. B. Howden be, and they are hereby appointed the members of such committee, with power to add to their number, three to constitute a quorum." He said several of the shareholders were thoroughly dissatisfied with the way in which the company had been managed. It was very important that it should be well managed, on account of the articles of association, which were such that he should have thought no honest man could have been found to establish a company under them. Having called attention to article 90, which held that no director, or intending director, should be disqualified by his office from contracting with the company, either as vendor or otherwise, he said all the articles were based on the same principles.

Mr. Buckingham seconded the amendment, and said he hoped the directors would accept it. He thought it would be folly to attempt to depreciate their own property, and that was not the object of the amendment; he thought, if properly handled, something might yet be made of the company. He was not sanguine that the directors thoroughly understood the business on which they were engaged, and before the infusion of new blood it was only fair that a committee of enquiry, offered in the most friendly way, should be appointed. He hoped no attempt would be made to refuse it, for if so he foresaw that something serious would occur. The first item that would be grappled with, he trusted, was the £137,500 for the contract with the Postmaster General paid to the combination representing that contract. For himself he thought if any of those to whom that was paid were in existence now, it was no other than right that they should refund at least £130,000; then there would be some chance of getting a fair dividend.

The Chairman said the board would accept the proposition of the shareholders most cordially. He then asked to be allowed to explain his position with the company. He was an original director, and his name appeared on the prospectus as deputy-chairman; but almost immediately he was appointed by the President of the United States a member of a foreign mission, and as there was a prospect that that would keep him out of this country for some months, he resigned his position rather than be responsible for launching a new business whilst he was abroad. About twelve months ago he was greatly pressed to take a seat at the board, but he declined; but upon being repeatedly urged he at length reluctantly consented, and since that time he had given an amount of time and care to the company that he could not be compensated for. When the chairman, Sir Julius Vogel, told him that he was going abroad again, he (Colonel Gouraud) said he felt that he really could not continue to be responsible for the management of the company as its chairman, and that he should offer his resignation. Sir Julius Vogel persuaded him to withhold it until the general meeting, and, therefore, when the new directors were appointed or the committee of investigation, his resignation would be placed in their hands, subject to their having access to him at all times to aid them in the labours contemplated.

The amendment was put as a resolution and carried unanimously.

A Shareholder asked whether Sir Julius Vogel received his fees whilst he was abroad.

The Secretary replied that he took a proportion at a reduced rate.

The Chairman moved the re-election of Sir Julius Vogel as a director, but this was negatived by a large majority.

Mr. Fitzgerald proposed the re-election of Sir Alexander Armstrong.

Mr. Stoop seconded, and the motion was carried unanimously.

Mr. Stoop moved the election of Messrs. H. Grewing, C. L. W. Fitzgerald, and A. Baker as directors.

The Chairman seconded, and the motion was agreed to.

Mr. Hurst moved and Mr. Dowling seconded the reappointment of Messrs. Deloitte, Dever, Griffiths & Co. as auditors.

A Shareholder said he thought the accounts very misleading, and should oppose the re-election of the auditors.

Eventually, an amendment deferring the motion was carried, after which the meeting was adjourned, the extraordinary general meeting called to follow it being also adjourned. A vote of thanks was accorded the chairman, and the meeting terminated.

The River Plate Telephone and Electric Light Company, Limited.—Respecting the meeting of this company convened for Thuesday afternoon, the following communication has been received:—

"The River Plate Telephone and Electric Light Company, Limited, 34, Wallbrook, E.C., May 28th.

"Sir,—I beg to inform you that the settlement of the account with the Consolidated Telephone Construction and Maintenance Company, Limited, referred to in the report having been subsequently found to require the confirmation of the shareholders of that company, and the meeting called for the purpose having been adjourned pending the report of a committee of the shareholders, it has been found desirable to postpone the meeting of this company fixed for the 29th inst. until after the decision of the Consolidated Company. The meeting called for the 29th inst. will, therefore, not be held, and a further notice will be issued calling a meeting at the earliest possible moment after the adjourned meeting of the Consolidated Company.

"Yours faithfully, R. Rodgers, Secretary."

Removals.—The South-Eastern Brush Electric Light and Power Company, Limited and Reduced, the Provincial Brush Electric Light and Power Company, Limited and Reduced, and the Consolidated Electric Company, Limited, have removed their offices to 68a, Cow Cross Street, E.C.

Stock Exchange.—Friday, May 30th, was appointed a special settling day in the vendors' shares of the London and Globe Telephone and Maintenance Company, Limited.

LATEST QUOTATIONS.

Authorised Issue.	Share.	Name.	Paid.	Closing Quotations, May 28.	Business Done.
		ELECTRIC LIGHT.			
40,000	10	Anglo-American Brush Co.	8	1⅛ - 1⅜	1⅛
		Do. Do.	10	3½ - 4	
30,000	5	Australasian E. L., Power & Storage Co.	3½	..	
24,300	10	British Insulite Co., Ld., "A" Shares..	6	..	
25,000	5	Gt. Western Electric Light & Power Co.	2½	⅜ - ½	
24,980	5	Hammond Elec. Lt. & Power Sply. Co.	5	½ - ⅝	
40,000	5	Indian & Ori. Electl. Storage Wks. Co.	2½	..	
250,000	1	Maxim-Weston Elec. Lt. & Power Co.	1	⅜ - ½	
100,000	5	Metrop. Brush Electric Lt. & Power Co.	3	..	
40,000	5	Pilsen-Joel & Gen. Elec. Lt. Co.	2½	..	
20,000	5	S. African Brush Elec. Lt. & Power Co.	2½	..	
100,000	5	Swan United Electric Light Co., Ld.	3	⅜ - ½	
		TELEGRAPHS.			
1,892,480*l.*	Stk.	Anglo-American, Limited	100	31½ - 32½	
2,553,760*l.*	Stk.	Do. Pref. } Def. receiving no div. until	100	58 - 59	
2,553,760*l.*	Stk.	Do. Def. } 6 p. c. paid to Pref.	100	6⅞ - 7⅛	6⅞
130,000	10	Brazilian Submarine, Limited	10	9⅛ - 10⅛	9 1/16
16,000	10	Cuba, Limited	10	9⅞ - 10⅛	
6,000	10	Do. 10 per cent. Preference	10	16½ - 17½	
13,000	10	Direct Spanish, Limited	9	4½ - 5	
6,000	10	Do. 10 per cent. Preference	10	14½ - 14¾	
65,000	20	Direct United States Cable, Ld., 1877	20	9½ - 10	
100,000*l.*	100	Do. 6 per cent. Deb., repayable 1884	100	98 -102	
380,000	10	Eastern, Limited	10	10⅝ - 11⅛	11 1/16, 11, 11 1/16, 11
70,000	10	Do. 6 per cent. Preference	10	13 - 13½	13⅜
200,000*l.*	100	Do. 5 do. Debs., repayable Aug. 1887	100	102-105	
200,000*l.*	100	Do. 5 do. do. Aug. 1909	100	103-107	
500,000	Stk.	Do. 4 do. Debenture Stock	100	94 - 97	95
250,000	10	Eastern Exten., Australasia & China, L.	10	11⅛ - 11¼	
320,000*l.*	100	Do. 6 p. c. Debs., repayable Feb. 1891	100	108 - 111	
500,000*l.*	100	Do. 5 p. c. (Aus. Gov. Sub.) Deb. 1900	100	104 - 107	
140,000*l.*	100	Do. do. reg., repayable 1900..	100	104 - 107	
100,000*l.*	100	Do. 5 per cent. Debenture, 1890	100	102 - 104	
550,000*l.*	100	{ Eastern & South African, Ld., 5 p. c. } Mort. Deb. Rg. redeemable 1 Jan. 1900 }	100	103 - 106	
	100	Do. do. To Bearer.	100	103 -106	
20,050	10	German Union Telegraph & Trust, Ld.	10	9⅞ - 10⅛	
250,000	10	Globe Telegraph & Trust, Ld.	10	6½ - 6⅝	6⅝, 5/8
250,000	10	Do. 6 per cent. Preference	10	12½ - 12⅝	12⅝
150,000	10	Great Northern	10	13⅜ - 13½	
100,000*l.*	100	Do. 5 per cent. Debentures	100	102 -105	
300,000*l.*	100	Do. 5 per cent. Debentures	100	102 -105	
81,200	10	India-Rubber, Gutta-Percha, & Tel. Wks.	10	22 - 23	23⅛
100,000	100	Do. 6 per cent. Debs., 1886	100	100 -105	
18,000	25	Indo-European, Limited	25	30½ - 31½	
40,000	10	London Platino-Brazilian, Limited	10	3½ - 3⅝	
100,000	100	Do. 6 per cent. Debentures	100	99 -101	
12,000	10	Mediterranean Extension, Limited	10	1½ - 1⅝	
3,200	10	Do. 8 per cent. Preference	10	2 - 4	
10,000	8	Reuter's, Limited	8	8 - 8½	
338,225*l.*	Stk.	Submarine	100	150 -160	
75,000	1	Do. Scrip	1	1⅛ - 1⅜	
4,200	Cert.	Submarine Cables Trust	100	98 -101	
37,350	12	Telegraph Construction and Mainten.	12	33 - 34	33½
150,000	100	Do. 6 per cent. Bonds, 1884	100	107 -109	107½
186,750	5	Do. 2nd Bonus Trust Cert.	2¾	1⅜ - 1⅝	
30,000	10	West Coast of America, Limited	10	6¼ - 6½	
150,000*l.*	100	Do. 8 per cent. Debs.	100	108 -110	
45,791	15	Western and Brazilian, Limited	15	52 - 54	
24,119	7½	Do. Preferred	7½	4⅜ - 4⅝	
24,119	7½	Do. Deferred	7½	⅝ - 1⅛	
200,000*l.*	100	Do. 6 p. c.. Debs. "A" 1910	100	102 -105	
250,000*l.*	100	Do. 6 p. c. Mort. Deb. B. '80, red. Feb. 1910	100	97 -100	
1,500	$1,000	Western Union 7 p. c. 1 Mort. (Bg.) Bds.	$1,000	121 -125	
1,050,000*l.*	100	Do. 6 per cent. Sterling Bonds	100	102 -105	
88,321	10	West India and Panama, Limited	10	⅝ - 1⅛	⅝, 1⅛
34,563	10	Do. 6 per cent. 1st Preference	10	6⅜ - 7	
4,669	10	Do. 6 do. 2nd do.	10	4⅜ - 5⅛	
		TELEPHONES.			
224,850	1	Con. Tele. & Mainten., L., Nos. to 154,165	1	⅛ - ¼	
225,000	1	Oriental Tele. Co., Nos. 80,001 to 300,000	1	⅛ - ¼	
100,000	5	United Telephone Co.	5	7⅞ - 8⅛	8
20,000	5	Do. New, issued at £2 pm.	2	..	

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

THE last ordinary general meeting for the season, of this society was held on Thursday, May 22nd, Professor W. G. ADAMS, F.R.S., President, in the chair. The minutes of the last ordinary general meeting having been read and confirmed, and the list of new and proposed new members announced, the President stated that the arrangements for a conference to be held at the Health Exhibition at South Kensington had been practically completed. The subjects to be discussed were "Electric lighting in relation to health," by Mr. R. E. Crompton; and "The application of electricity to medical purposes," by Dr. Stone. The meeting would be held in the morning at 11 o'clock, on July 3rd, and in the afternoon at 2.30. Due notice will be given of the meeting, and the necessary tickets for admission would be forwarded.

A paper was then read by Mr. W. H. PREECE, F.R.S., on "The Electrical Congresses of Paris." The year 1881 marks an epoch in the history of electrical science, as in that year the French Government (to whom great credit was due) contributed the sum of 300,000 francs towards the holding of an Electrical Exhibition and Congress in Paris. The practical object of this was to codify electrical science and to sound its depths. No less than 293 electricians and scientific men met in Paris on this occasion; of these, 70 were French, 38 English, 32 Belgian, 15 German, and the remainder of various other nationalities; scarcely any scientific luminary of standing was absent. There were present, amongst others, Sir William Thomson, Helmholtz, Kirchoff, Rowland, Dumas, Lenz, and Dubois Raymond. A marked feature of this Congress, and of those subsequently held, was the wonderful organisation; the latter being due to the skill and tact of M. Cochery. The congress was divided into three sections, which had severally under consideration:—1. "The dimensions of the electrical units." 2. "Questions relating to telegraphy and telephony, and the application of electricity to railway purposes." 3. "Electric lighting, electro-physiology, lightning conductors, the transmission of power, clocks, metallurgy, &c." The conferences lasted from September 15th to October 15th, and eight full meetings were held. The first Congress afforded a great opportunity for anyone to give his opinion on the subjects under consideration, and the first great result was the acceptance of the English absolute system of units based on the C.G.S. The second result was the statement of what should be the accepted dimensions of the "Ampère," the "Farad," the "Coulomb," and the "Volt." It was then decided that a second Congress should be held in Paris to settle the exact value of the Ohm, and to organise a system of earth current observations, and also to fix upon a standard of light. The number of persons present at the various conferences was too great to enable real sound work to be done, and what was actually of practical value was done at the subsequent Congresses. The second Congress was held in October, 1882, there being 45 representatives present. England was represented by Sir William Thomson. The subjects discussed were:—1. The units. 2. Atmospheric electricity and earth currents; and 3. The standard of light. Again no definite decisions were arrived at, although the subjects were thoroughly discussed. In the meantime, only one scientist (Lord Rayleigh) had devoted any attention to the determination of the exact value of the ohm; and, although great confidence was felt in the accuracy of the results obtained, yet, seeing the importance of the subject, it was felt that it was desirable that another Congress should be held before an absolute decision was arrived at. This Congress was held in the present year, under the presidency of M. Cochery. The President of the Republic received the delegates, and his speech made on this occasion will be printed in the Journal of the society. England on this occasion was represented, amongst others, by Sir William Thomson, Professor Forbes, Professor Adams, Mr. E. Graves, Professor Fleeming-Jenkin, Professor Hughes, and Captain Abney. The work was thoroughly well done, and the conclusions come to were just and reliable. With reference to the question of the units, the chief point was to determine the length of a column of mercury of one square millimetre section which should represent the ohm. To know the exact value of the latter is a most important point, otherwise it would be impossible to make measurements with exactness. The author then explained the relation of the units with reference to "energy," and stated that nothing had established the doctrine of energy so much as the C.G.S. system of units. This system was suggested by Gauss and Weber in 1832. Joule also did subsequently a marvellous amount of work with reference to the question. The latter established a unit of current which approximated to the present unit. The Joule unit (proposed 40 years ago) being the current required to decompose a chemical equivalent in 1 hour, this was equal to 1·8 ampères of current. Sir William Thomson had testified to the almost *magical* accuracy of Joule's results. In 1861, in a very able paper, Sir Charles Bright and Mr. Latimer Clark proposed a system of units, and gave names to them, viz., the "Ohmad," "Farad," "Weber," and "Volt." These names were practically adopted by the Committee of the British Association, which had been formed at the instigation of Sir William Thomson. The labours of this committee are models of the way to carry out such work. In Germany, Dr. Werner Siemens had worked at the question of the units, and although the Paris Congress did not adopt the particular unit suggested by him, they adopted the use of a mercury column. The author then criticised the present English standards of length, and pointed out the existence of a misunderstanding which seemed to exist to some extent as to the "metrical" being the same as the "decimal" system; the two had, of course, different meanings entirely. A general adoption of the metrical system could, he considered, be easily effected, as the only objection to it was a want of familiarity, which would soon disappear. At the present time workmen, from constant practice, are well acquainted with the dimensions of the electrical units, The author then explained the general principles on which the actual values of the units are arrived at. The mean of Lord Rayleigh's results showed the ohm to be equal to a column of mercury one square millimetre in section and 106·33 centimetres long. Mascart made the length to be 106·27. Several physicists, however, thought that the results were slightly too high, and in deference to these it was finally decided that the length should be 106 centimetres, although this value does not represent the true ohm. The resolution passed by the Congress was, therefore, "that the *legal* ohm was the resistance of a column of mercury of one square millimetre section, and 106 centimetres long, at the temperature of melting ice." It was also agreed that the unit of current should be 10^{-1} absolute units, and that the volt should be the electromotive force which would give one ampère of current through one ohm. The "Congress" ohm is actually 1·0114 of the old B.A. unit. This difference could be allowed for by altering the temperature marked on the old resistance coils to a higher value. The suggestion that the watt should be adopted as a unit of power did not commend itself to the Congress, partly (said the author) because there is no "w" in the French language. The question of "Atmospheric Electricity," although discussed, did not result in any very definite conclusions, although it was recommended that any results obtained should be forwarded to Berne to be digested, and then copies sent round to all the States. The question of earth currents was also dealt with in a similar manner. Very little progress had been made in this subject, the only recent discovery which had been made being that the scintillations of the stars apparently coincided in time with the existence of earth currents. He would mention that a catalogue of all the works dealing with the question of earth currents had been compiled by Mr. Frost, the society's librarian. The last subject discussed was that of a "Standard of Light," and the one which it was agreed to adopt was that of M. Violle,* namely, the light emitted by a square centimetre of melted platinum at the point of solidification. This standard, in the author's opinion, was no standard at all, and he did not think it at all practical. Captain Abney, who had attended the Congress with especial reference to the subject, was unfortunately not prepared at the time to discuss the matter; both the author and he had been making experiments with the object of producing a standard from an incandescence lamp, which had the advantage that it could be expressed in watts. In conclusion, he would state that the Congress had proved that some points, at least, could be amicably settled, and it had resulted in great good through the friendships that were made. Much knowledge had been gained, and business had been greatly facilitated. Altogether the results of the Congress would leave a very distinct impress on the sands of time.

In the discussion which followed the reading of the paper,

Prof. ADAMS stated that there were eight determinations of the value of the ohm made in 1882 and 14 since, or 22 in all. Nineteen of these determinations agreed very closely, and in no cases were there greater differences than 1 per cent. He thought that the delay which had taken place in settling the question had been of great benefit, as it had enabled such a large number of observations to be made. There were actually six distinct methods of determining the value of the ohm; Joule's result, made 20 years ago, gave the value as 106·23 centimetres of a column of mercury one square millimetre in section; this result was extraordinarily close to the recent determination of Lord Rayleigh, who made the length to be 106·24 centimetres.

Sir WILLIAM THOMSON said that although he did not consider the value 106 so close to the correct value of the ohm as 106·2, yet inasmuch as there were considerable differences of opinion as to what was really the right value, he quite appreciated the difficulties of satisfying all, and consequently he readily acquiesced in the final decision of the Congress. He thought that in the course of a few years the value of the ohm would be determined with certainty to the fourth decimal place, but whatever change resulted from this would be of no great practical inconvenience. He did not agree with Mr. Preece with reference to the standard of light. Violle's standard was adopted because no other was suggested, and because the results of experiments proved that the standard was quite reliable. If Violle was able to reproduce the standard, there was no reason why anyone else should not do it also. It was true that an expense of £250 might be incurred in the necessary apparatus, but he doubted whether the incandescence lamp standard recommended by Mr. Preece would not be equally costly if all the expenses were considered. He denied the practicability of such a standard, seeing the extreme difficulty of measuring the thickness of the incandescent filament. He thought that a determination of the proportion between the intensity of the different colours at different temperatures in a filament might lead to some useful results. The perfectness of the vacuum in a lamp makes a very great difference in the amount of light emitted, but no doubt great perfection in this respect is gradually being arrived at. Captain Abney's standard required a knowledge of the exact area of the exposed filament, and the ratio between the two colours

* ELECTRICAL REVIEW, May 24th, page 432.

of light when different amounts of energy were being expended. In conclusion, he would again express his opinion that Violle's standard was by no means an impracticable one, and being reliable it could be at once adopted without waiting for future discoveries.

The meeting then adjourned.

Physical Society, May 24th.

New Member: Mr. F. C. Phillips, Electric Engineer.

Prof. W. G. ADAMS took the chair while the President, Dr. GUTHRIE, gave a brief summary of his recent researches on entectic alloys, that is, alloys of low fusing point. The complete research will be published in the society's proceedings.

Dr. GUTHRIE showed by means of tables and curves of results that mixtures of water and nitre, nitre and nitrates, &c., behaved in the same way as fusible alloys, such as alloys of lead and bismuth. On cooling down the alloy or mixture, the ingredient present in richer quantity crystallised out. There seemed to be no definite molecular proportions in these alloys. A "tetra-entectic" alloy of bismuth 47·38, tin 19·97, lead 19·36, cadmium 13·29 per cent. was exhibited by the author which fused at 71°, or in boiling alcohol. Rose's fusible metal melts at 93°. Results were given of the behaviour of mixtures of water and the aniline salts, salicylate, oxalate, &c.; also of water and tri-ethylamine and other members of the ammonia group. Dr. Guthrie's observations tended to show that fusion and solution were of the same nature. He pointed out their bearing on mineralogy and geology, and inferred that water in igneous rocks was there from the first and not by infiltration, as some suppose.

The President then took the chair, and

Dr. W. H. STONE exhibited a simple, cheap and portable galvanometer for hospital use, made of a boxwood cylinder with coils wound round it, and a needle, with mirror, inserted into a test tube and pushed into the hollow of the cylinder. The needle is made dead beat by putting paraffin oil into the tube. He also exhibited a Kohlrausch metre bridge for alternating currents, a telephone playing the part of indicator. Dr. Stone employs it for measuring the resistance of the human body, which he finds to be less than 1,000 ohms. With high tension currents it appears lower than with low tension currents. Another metre bridge of the kind with a longer wire (three metres in this case as compared with 14 metres in the other), was also shown in connection with a sledge induction coil by which the power of the current can be regulated to suit the patient. Dr. Stone stated that the body acts more like a solid than a liquid conductor.

Mr. GLAZEBROOK said he had used a similar plan with a telephone to measure the resistance of electrolytes; but found the telephone too sensitive from induction, though in Dr. Stone's work this objection might not apply.

Prof. G. FORBES stated that the telephone had been applied in a similar way to comparing capacities.

With regard to the danger from currents Prof. AYRTON said the E.M.F. of the railway current at Bushmills was 250 volts, and pointed out that very intermittent currents were more dangerous than fairly continuous ones.

Dr. STONE thought that with good skin contact (as with salt and water) this E.M.F. would be dangerous.

Mr. LECHY instanced the reported death of a horse at Bushmills by a shock.

A new speed indicator, especially for marine engines, was exhibited by Mr. W. T. GOOLDEN and Sir A. CAMPBELL, of Blythswood. Its action depended on the rolling of a disc on a cone, the disc traversing a screw driven by the engine-shaft. The disc forms the nut of the screw, and rotates in an opposite direction to the latter. Its position on the screw depends on the surface velocity of the cone, which is kept turning at a uniform rate by clockwork. In travelling, the disc makes a series of electric contacts which indicate its position on a set of dials detatched. Recording apparatus can be added. The apparatus was made by Mr. A. Hilger.

Mr. W. BAILY exhibited a similar device in which the cone was replaced by a circular plane or disc. He had invented this independently, and it had the advantage of giving a zero position to the rolling disc, though the cone was the more compact arrangement. The idea of using a screw in this manner was suggested by Mr. Shaw, of Bristol, some three years ago.

NEW PATENTS—1884.

8044. "Utilising telephone and telegraph systems for fire alarum purposes." E. A. PARIS, W. H. SCOTT. Dated May 22.

8063. "Arc regulator lamp apparatus." R. E. B. CROMPTON, T. CRABB. Dated May 22.

8077. "Insulating compounds for electrical purposes." A. MUIRHEAD. Dated May 22.

8090. "Method of electrically transmitting drawings, prints, pictures, and the like, and apparatus therefor." E. A. SCHAEFFER. Dated May 22.

8096. "Means for fixing incandescent lamps in position." H. EDMUNDS. Dated May 22.

8115. "Carrying and insulating electric telegraph and telephone wires and electric light and power wires." J. C. SELLARS. Dated May 23.

8143. "Switch for electric light circuits." H. FARADAY. Dated May 23.

8169. "Incandescent electric light lamp holders." C. G. and F. SMITH. Dated May 26.

8213. "Porous cells for galvanic batteries." P. JENSEN. (Communicated by G. Przibram.) Dated May 26.

8224. "Electro telegraphic system particularly applicable for long cables." S. ROOS. Dated May 26.

8241. "Telephones." M. KOTYRA. Dated May 26.

8243. "Fittings and holders for incandescent lamps." F. H. VARLEY, W. BEALE, R. H. PADBURY, J. R. SHEARER. Dated May 26.

8273. "Portable galvanic batteries." S. H. EMMENS, United Patents Corporation. Dated May 27.

8275. "Electric wheel." S. H. EMMENS, O. MARCH, United Patents Corporation. Dated May 27.

8283. "Suspending the shades of incandescent electric lamps." G. SPERRYN. Dated May 27.

8305. "Apparatus for indicating the proper working of electrical annunciators." J. K. D. MACKENZIE. Dated May 27.

8307. "Contact devices for electric apparatus." W. R. LAKE. (Communicated by C. F. de Redon.) Dated May 27.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1883.

4612. "Electric accumulators." G. F. REDFERN. A communication from D. Lontin, of Paris.) Dated Sept. 27. 2d. This invention of improvements in electric accumulators is based on the decomposition of alkaline salts by means of an electric current, and in carrying out this invention the accumulator is formed of one or several sheets of amalgamated zinc opposed to sheets of lead. The whole is immersed in a solution of alkaline salt, through which is passed an electric current. The alkaline metal will deposit in the mercury of the amalgamated zinc, and its oxygen will be carried to the lead, and will form a peroxyde of lead. (*Provisional only.*)

4638. "Electro-motors." O. MARCH and F. CHEESWRIGHT. Dated September 28. 6d. On the main shaft of the machine the inventors fix one or more discs, around the peripheries of which they fix a number of electro-magnets parallel to the shaft, and instead of connecting these in series as is customary, where two or more magnets are used for motors, they connect the magnets of each disc in one or more multiple arcs, which may be readily varied by means of any suitable mechanical device, so as to allow of the internal resistance being altered to suit circumstances, and thereby diminish the resistance of the circuit to any desired extent. Each set of magnets is arranged to face a corresponding set on a fixed framework surrounding the shaft, and where two discs or more are used, they fix them on the shaft in such a manner that the magnets of each disc shall always occupy a position, circumferentially interspaced with those of the other discs. Alternatively they interspace the magnets of the fixed frames instead of those of the discs. The inventors then arrange any suitable form of commutator to divert the current through each set of moving and fixed magnets in succession, at the points or periods of greatest efficiency. By this means they are able to continually utilise the current, without any dead points or cut outs, as is generally the case. The inventors provide a ready means of reversal by mounting the contact brushes on a pivotted co-radial frame, so that the brushes may be readily moved from one section to another of the commutator.

4683. "Electro-motors." S. J. COXETER and H. NEHMER. Dated October 2. 6d. The inventors make the motor with an armature that has the shape of a short cylinder, with a large circumference, in order to obtain better centrifugal force; and they also confine the magnetic field within a narrow space.

4694. "Transmitting and receiving audible messages or signals by electricity." A. F. ST. GEORGE. Dated October 2. 2d. Relates to telephones, or apparatus used for transmitting and receiving audible messages by means of electricity, and it has for its objects novel methods of constructing and arranging such apparatus so that it is very simple, cheap, and effective. (*Provisional only.*)

4726. "Cables for transmitting electric currents, &c." F. C. GUILLEAUME. Dated October 4. 6d. The inventor first twists five insulated copper wires round a non-insulated sixth wire of cast steel of great tensile strength which serves both for earth-connection and as straining-wire. The 5 insulated wires may each be taped with tin-foil or any other suitable conducting material before being stranded, or the strand of 5 insulated wires may be taped with tin-foil or other suitable conducting material. He then twists 5 such tin-foil-taped strands round a core consisting of a strand of 7 or any other suitable number of cast-steel wires of great tensile strength taped with tin-foil, or any other suitable conducting

material, and likewise serving both for earth connection and for straining purposes. The cable which is thus formed of 25 insulated wires is then taped with prepared insulating tape, and streaked with lead or any other suitable material, over which is provided a coating of asphalted or otherwise prepared tape or yarn with a coat of white paint.

1884.

4032. "An improvement in a galvanic battery." H. FAIRFAX. Dated February 27. 2d. This invention is an improvement on a former patent (2405, A.D. 1884). In substituting for caustic soda, or adding to the solution of caustic soda a solution of hyposulphite of soda, sulphurous acid, or some other analogous substance, in order to absorb the oxygen generated in the soda division of the battery; and in substituting for sulphuric acid, or adding to the solution of sulphuric acid, nitric acid; or adding bichromate of potash to the sulphuric acid division of the battery in order to absorb the hydrogen generated in this division.

4042. "Improved means for enabling electric arc lamps to be used advantageously in parallel circuit with one another or with incandescent lamps." J. E. H. GORDON. Dated February 27. 6d. The inventor interposes in each of the parallel branch circuits in which an arc lamp is placed an inductive resistance coil, whose true resistance is small, and which will allow without much waste a considerable current to pass through it and through the lamp, but which has a large co-efficient of self-induction, so that if the resistance of the lamp be cut out, as when the carbons of the lamp touch or approach too close together, the amount of current which can then pass will rapidly reach a maximum of but moderate strength in excess of that previously required for the lamp. Such an inductive resistance coil can be formed of an insulated conductor which is of sufficient size not to in itself interpose much resistance to the passage of the current, and which is wound in adjacent coils around a core of soft iron. By making the core of sufficient size and a suitable shape, the resistance coil can be adjusted so as to allow of the amount of current required for the lamp being passed through it with but little loss, but so as not to allow of the passage of a much greater strength of current.

4296. "Improvements in microphones." A. J. BOULT. (Communicated from abroad by K. S. Dembinski, of Brussels.) Dated March 3. 4d. The object sought to be attained by this invention is to render the microphone constructed in accordance therewith extremely sensitive, and this to a higher degree than has heretofore been practicable. Moreover, when the apparatus has been once adjusted it is not liable to get out of order again; it is, moreover, so solidly constructed, that it will bear heavy shocks without injury.

4346. "Improvements in and relating to insulating materials or compounds for electrical conductors. W. R. LAKE. (Communicated from abroad by Thomas Shaw Leigh, of America.) Dated March 4. 2d. According to the said invention, what the inventor terms metallic soap is first prepared, its preparation may be accomplished in various ways, the following being most suitable: one pound of common brown soap is thoroughly dissolved in two gallons of hot water. In another vessel, one and a quarter pounds of alum are thoroughly dissolved in two gallons of hot water. The dissolved soap and alum are now mixed together, the result being a flocculent mass of metallic soap, which is afterwards removed from the water and dried by any suitable means. The metallic soap is dissolved in benzine, turpentine, or gasoline, one gallon thereof being employed to one pound of the soap, and to the same is added one gallon of boiled linseed oil, all these ingredients being well stirred together. Half a gallon of copal varnish or any other good varnish is also added and well stirred with the previous mixture of metallic soap and boiled linseed oil. The proportions of the different ingredients may be varied as required. The solution is now adapted for saturating cotton, silk, or other fibrous coverings for electrical wires, thus rendering the said coverings water-proof and electrically insulating the wires in a durable and inexpensive manner, the application being easily effected.

4365. "Improvement in lead-armoured electric cables, and in mandrels for manufacturing the same." R. S. WARING. Dated March 4. 6d. Relates to certain improvements in metal-covered cables, and in general terms it consists of a cable having its insulating conducting wires enclosed in separate tubular passages in a common body of metal, the wires being arranged in a novel manner or method, whereby flow of metal to form the inner walls of covering around the wires is facilitated, and the invention further consists of a cable having a body or covering of metal with the number of tubular passages therethrough within which the insulated wires are enclosed, such wires being arranged in pairs of rows, the two rows of a pair being in closer proximity than the adjacent rows of succeeding pairs, and also closer than the adjacent wires, in a single row.

4366. "Improvement in lead-armoured electric cables, and in mandrels for manufacturing the same." R. S. WARING. Dated

March 4. 6d. Relates to certain improvements in compound-electric cables, and, in general terms, consists of a body of lead or other equivalent soft, ductile metal or alloy, such body having passages therethrough enclosing insulated conducting wires, the wires being arranged in a series of groups in circular order around a central group. The fig. shows one form of the cable.

4367. "Electric cables, and in mandrels for manufacturing the same." R. S. WARING. Dated March 4. 6d. Relates to certain improvements in compound electric cables, covered with a soft metal, and to the method of manufacturing the same.

4368. "An improvement in electric cables, and in mandrels for manufacturing the same. R. S. WARING. Dated March 4. 6d. Relates to certain improvements in compound-electric cables designed more particularly for use in water, and in general terms it consists of a cable having a solid as distinguished from a tubular body of soft ductile metal or equivalent alloy, such body enclosing insulated conducting wires, and also a series of strengthening wires each within its appropriate passage through the body, the conducting wires being arranged in close proximity around the solid core of soft metal, and the strengthening wires being arranged in circular order around the conducting wires. The purpose of the present invention is to secure a cheap cable by employing a small quantity of lead, and so disposing the same as to utilise it to the best advantage.

4369. "Improvement in making branches or loops, and in repairing defects in lead-armoured electric cables." R. S. WARING. Dated March 4. 6d. Relates to certain improvements in making joints for branches or loops leading from a lead-covered, electric cable.

4370. "Improvements in mandrels and dies for manufacturing lead-armoured cables." R. S. WARING. Dated March 4. 6d. Relates to mandrels and dies for manufacturing lead-armoured cables.

4371. "Improvement in mandrels for manufacturing lead-armoured electric cables. R. S. WARING. Dated March 4. 6d. Relates to mandrels for manufacturing lead-armoured electric cables.

4685. "Mechanism for driving dynamo electric machines." W. P. Thompson. (Communicated from abroad by J. B. Wayne and J. R. Markle, of America.) Dated March 11. 4d. This invention aims to equalise the speed of the armature; and it consists in attaching to the crank shaft a friction pulley, which engages with a friction pinion placed on the armature-shaft, or on a counter-shaft provided with a heavy belt-pulley, when more speed is required than can be obtained by direct connection with the armature shaft.

5029. "Improvements in galvanometers." J. BLYTH. Dated March 18. 6d. Consists principally in employing an endless or circular solenoid as the medium by which an electric current is made to act on a small suspended magnet or needle for the purpose of obtaining an indication or measurement of the strength of the current as shown by the deflection or angular movement of the magnet.

CORRESPONDENCE.

Telephone Patents.

In answer to the question of Mr. F. Williams, contained in your last week's issue, the view of the Courts upon the subject appears to be this, viz.—that when a patent is for a new *combination* of machinery, *every part being old*, the making of the separate parts in this country for exportation does not constitute an infringement; but that the case is different where the parts themselves are new, and claimed as such. (See Goucher *v.* Clayton in "Goodeve's Abstract of Patent Cases," p. 147.) To carry this to its legitimate conclusion, it would certainly seem that, assuming the parts of the telephones in question are not claimed *per se*, those parts could be made in this country separately and exported. The observations of the learned Judge in the case to which I refer are, however, only *dicta*, and scarcely amount to a decision, so that it would not be safe to risk too much upon them. In any event, I think there is a palpable difference between the manufacture of the case and the manufacture of the other parts of the telephone. The case is merely a receptacle, and the instrument may be considered as complete without it, whereas it is the other parts which really constitute the instrument.

It is scarcely necessary for me to add, that even assuming the whole of the parts of the telephone could be made without let or hindrance, the putting of these parts together here would constitute an infringement.

T. J. Handford.

42, Southampton Buildings, W.C.,
May 28th.